LAW AND NEUROSCIENCE 2.0

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INTRODUCTION

Law and neuroscience is approaching an inflection point. It has been roughly ten years since the *New York Times Magazine* put neurolaw on its cover,[1] since Stanford neuroscientist Robert Sapolsky wrote his seminal article, "The Frontal Cortex and the Criminal Justice System";[2] and since law professor Adam Kolber taught the first law and neuroscience course. The MacArthur Foundation Research Network on Law and Neuroscience, which has been one of the epicenters of the field over this same period, will wind down its primary research projects soon.[3]

So what comes next?

In this Article, I sketch out a vision for "Law and Neuroscience 2.0."[4] Neurolaw has built a solid foundation for a lasting intellectual and policy endeavor. But to realize the promise of neuroscience for law and policy, we need to do more to productively encompass the wide variety of ideas, research, and activity that are on-going and forthcoming at the neuroscience-law intersection. At the ten-year mark, neurolaw too often focuses only on criminal responsibility, too infrequently explores technologies beyond fMRI,

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1. Jeffrey Rosen, *The Brain on the Stand*, N.Y. TIMES MAG. (Mar. 11, 2007), http://www.nytimes.com/2007/03/11/magazine/11Neurolaw.t.html.

2. Robert M. Sapolsky, *The Frontal Cortex and the Criminal Justice System*, 359 PHIL. TRANSACTIONS ROYAL SOC'Y LONDON B: BIOLOGICAL SCI. 1787, 1787–88 (2004).

3. *See* Jim Patterson, *Law and Neuroscience Research Gets $1.4 Million in Additional Grant Money*, VAND. U. (Sept. 14, 2015, 12:21 PM), http://news.vanderbilt.edu/2015/09/law-and-neuroscience-research-gets-1-4-million-in-additional-grant-money/.

4. I do not mean to suggest that this is only the second phase of law and neuroscience. As I have written elsewhere, the history of neurolaw stretches back centuries. Francis X. Shen, *The Overlooked History of Neurolaw*, 85 FORDHAM L. REV. 667 (2016).

and has yet to explore many of the ways in which brain science already is posing legal challenges. In short, there is much to do.

The Article proceeds in four parts. Part I provides a brief review of the past decade of law and neuroscience research, distilling some of the lessons we have learned and some of the challenges we have faced. In Part II, I explore the landscape of future neurolaw possibility, offering fifteen different areas of potential investigation. Part III begins to develop a blueprint for how we can get from here to there, with an emphasis on the need for educating a new generation of neuroscience-informed legal thinkers, and creating viable career tracks for those graduates. I conclude in Part IV with a short reflection on why—despite all its limitations—the future of neurolaw is bright.

I. WHAT HAVE WE ACCOMPLISHED? A BRIEF LOOK BACK AT LAW AND NEUROSCIENCE 1.0

In the literature on human development, the age of eight to twelve is known as "middle childhood."[5] In middle childhood, humans are still children, not yet adults. But development in this period is foundational for what lies ahead: adolescence, young adulthood, and finally being all grown up.[6] It strikes me that this is a useful way to view the present state of law and neuroscience: about ten years into our efforts, we are in our middle childhood. In this Part, I suggest that we have built strong foundations, suitable for facilitating much further development in the decades to follow. I also suggest, however, that there are challenges to address.

A. Covered a Lot of Ground

As I have recently argued elsewhere, brain science and law have been interacting as far back as (at least) the 19th century.[7] It might be fair to say, therefore, that there have been several previous waves, rather than a single Law and Neuroscience 1.0. But however we label these historical moments, it is abundantly clear that much ground has been covered.[8]

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5. DEVELOPMENT DURING MIDDLE CHILDHOOD: THE YEARS FROM SIX TO TWELVE 1 (W. Andrew Collins ed., 1984).

6. *Id.*

7. Shen, *supra* note 4.

8. For an overview see OWEN D. JONES ET AL., LAW AND NEUROSCIENCE (2014), and for a bibliography visit *Law and Neuroscience Bibliography*, MACARTHUR FOUND. RES. NETWORK ON L. & NEUROSCIENCE, http://www.lawneuro.org/bibliography.php (last visited Jan. 15, 2017); *see also* Francis X. Shen, *The Law and Neuroscience Bibliography: Navigating the Emerging Field of Neurolaw*, 38 INT'L J. LEGAL INFO. 352, 352–54 (2010).

Scholarship and case law have intersected with brain death, brain injury, criminal responsibility, criminal treatment, decision-making, bias, pain, evidence law, addiction, mental health law, disability law, insurance law, genetics, evolution, memory, emotions, and much more. Scholarship has been theoretical, empirical, international, and intensely interdisciplinary. New ideas have sprung forth from a variety of fields, including law and neuroeconomics,[9] law and behavioral biology,[10] and law and behavioral genetics.[11] At the same time, the parallel field of neuroethics has developed a research profile that included legal issues.[12] Cases have been heard in local counties all the way up to the Supreme Court.[13] One of the most prominent neurolaw case of the last ten years was the *Semrau* case,[14] in which a federal court held an extensive *Daubert* hearing and ultimately concluded that the proffered fMRI-based lie detection evidence should be excluded.[15]

There is not enough space to do justice to the breadth of this work, so I focus below on the main current of recent neurolaw dialogue: criminal responsibility.

B. Productive Dialogue About Criminal Responsibility

From its origins in the 19th century through its rise in the last decade, the bulk of scholarship in law and neuroscience has related, in one way or another, to the criminal law.[16] The modern dialogue was sparked, initially, by the 1991 case of Herbert Weinstein, a New York advertising executive who

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9. *See, e.g.*, Terrence R. Chorvat et al., *Law and Neuroeconomics*, 13 SUP. CT. ECON. REV. 35, 36–38 (2005); Morris B. Hoffman, *The Neuroeconomic Path of the Law*, *in* LAW AND THE BRAIN 3 (Semir Zeki & Oliver Goodenough eds., 2006).

10. *See, e.g.*, Owen D. Jones & Timothy H. Goldsmith, *Law and Behavioral Biology*, 105 COLUM. L. REV. 405, 407–11 (2005).

11. *See, e.g.*, Nita A. Farahany & James E. Coleman, Jr., *Genetics and Responsibility: To Know the Criminal from the Crime*, 69 L. & CONTEMP. PROBS. 115, 115–18 (2006); Brent Garland & Mark S. Frankel, *Considering Convergence: A Policy Dialogue About Behavioral Genetics, Neuroscience, and Law*, 69 L. & CONTEMP. PROBS. 101, 101–02 (2006); Owen D. Jones, *Behavioral Genetics and Crime, in Context*, 69 L. & CONTEMP. PROBS. 81, 81–85 (2006).

12. *See, e.g.*, SCIENTIFIC AND PHILOSOPHICAL PERSPECTIVES IN NEUROETHICS, at xxv, xxvii (James J. Giordano & Bert Gordijn eds., 2010); THE OXFORD HANDBOOK OF NEUROETHICS (Judy Illes & Barbara J. Sahakian eds., 2011); Martha J. Farah, *Emerging Ethical Issues in Neuroscience*, 5 NATURE NEUROSCIENCE 1123, 1123 (2002).

13. *See, e.g.*, Brown v. Entm't Merch. Ass'n, 564 U.S. 786 (2011).

14. United States v. Semrau, 693 F.3d 510, 523–24 (6th Cir. 2012).

15. United States v. Semrau, No. 2:10-cr-10074-JPM, 2011 WL 9258 (W.D. Tenn. Jan. 3, 2011). For discussion of the case, see Francis X. Shen & Owen D. Jones, *Brain Scans as Evidence: Truths, Proofs, Lies, and Lessons*, 62 MERCER L. REV. 861, 871 (2011).

16. *See* Shen, *supra* note 4 (discussing early origins of neurolaw and criminal responsibility dialogue).

strangled his wife, pled insanity, and attempted to introduce brain imaging evidence in his defense.[17] The case drew the attention of scholars, some of whom convened in 1995 for a panel on Neuropsychiatry in the Courtroom. Out of that panel came Stephen Morse's 1996 article, *Brain and Blame*.[18]

Morse argued persuasively that explanations of behavior are not per se excuses.[19] For Morse, and for many courts, neuroscience was the latest in a long series of failed attempts to explain away criminal responsibility.[20] Morse rejected neuroscientific-based theories of determinism as both unhelpful and not novel.[21] And in a series of articles, book chapters, and public panels, Morse emphasized that neuroscience had nothing to offer the criminal law.[22] Law professor and criminologist Deborah Denno similarly argued about the same time "that social science research has not successfully demonstrated sufficiently strong links between biological factors and criminal behavior to warrant major consideration in determining criminal responsibility."[23]

Although it drew the attention of some scholars, the 1992 Weinstein case was not a watershed moment for neuroscientific evidence in court. Courts in the 1990s were seeing neuropsychological testimony in brain injury cases, but relatively little in the criminal domain. Neurolaw scholarship in the 1990s

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17. People v. Weinstein, 591 N.Y.S.2d 715, 718 (App. Div. 1992). For discussion of the case see JONES ET AL., *supra* note 8, at 41–67.

18. Stephen J. Morse, *Brain and Blame*, 84 GEO. L.J. 527, 527 (1996).

19. *Id.* ("I suggest in contrast that abnormal biological causes of behavior are not grounds per se to excuse. Causation is not an excuse and, even within a more sophisticated theory of excuse, pathology will usually play a limited role in supporting an individual excuse.").

20. As he had written a decade before the Weinstein case, "[a]t various times, Fate, humors, incubi, succubi, the gods, the devil, genetics, parents, unconscious conflicts and structures, the will, social structure, brain anatomy and physiology, contingencies of reinforcement, and combinations of the above have been advanced as explanatory factors" for human behavior. Stephen J. Morse, *Failed Explanations and Criminal Responsibility: Experts and the Unconscious*, 68 VA. L. REV. 971, 972 (1982).

21. *See* Stephen J. Morse, *Culpability and Control*, 142 U. PA. L. REV. 1587, 1592 (1994). In 1994 Morse had already anticipated where neuroenthusiasts would take things: "the criminal law might treat persons as part of the biophysical flotsam and jetsam of the universe and respond solely on the basis of the type and degree of dangerousness people threaten, without regard to moral responsibility." *Id.* at 1589.

22. *See, e.g.*, Stephen J. Morse, *Avoiding Irrational Neurolaw Exuberance: A Plea for Neuromodesty*, 62 MERCER L. REV. 837, 837–38 (2011); Stephen J. Morse, *Criminal Law and Common Sense: An Essay on the Perils and Promise of Neuroscience*, 99 MARQ. L. REV. 39, 54–68 (2015); Stephen J. Morse, *Criminal Responsibility and the Disappearing Person*, 28 CARDOZO L. REV. 2545, 2545–46 (2007); Stephen J. Morse, *Determinism and the Death of Folk Psychology: Two Challenges to Responsibility from Neuroscience*, 9 MINN. J.L. SCI. & TECH. 1, 1–3 (2008).

23. Deborah W. Denno, Comment, *Human Biology and Criminal Responsibility: Free Will or Free Ride?*, 137 U. PA. L. REV. 615, 617 (1988).

was primarily in areas such as brain death and brain injury, and not the criminal law.[24]

Things began to change in the early 2000s, with a series of important articles. In 2001, law professor Oliver Goodenough published the Jurimetrics article, *Mapping Cortical Areas Associated with Legal Reasoning and Moral Intuition*.[25] Goodenough argued that "[a]dvances in neuroscience and other branches of behavioral biology provide new tools and the opportunity to revisit classic questions at the foundation of legal thinking."[26] Goodenough went on to propose a series of experiments that would explore the neural architecture of moral and legal reasoning.[27]

Others too had the idea that neuroscience had something to offer law. The Dana Foundation soon published an edited volume on "Neuroscience and the Law" in 2004, and other articles and volumes followed.[28] Most notable was the 2004 special issue on Law and the Brain in the *Philosophical Transactions of the Royal Society B*, co-edited by Goodenough and neurobiologist Semir Zeki.[29] The issue was the "first serious attempt by a major scientific journal to address questions of law as reflecting brain activity and, conversely, to emphasize that it is the organization and functioning of the brain that determines how we enact and obey laws."[30]

What stood out about the volume was that it included contributions from neuroscientists themselves. Two contributions proved especially important for the field. First, neuroscientists Joshua Greene and Jonathan Cohen argued that "for the law, neuroscience changes nothing and everything."[31] Taking a provocative, neuro-deterministic position, Greene and Cohen suggested that

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24. J. Sherrod Taylor, *Neurolaw and Traumatic Brain Injury: Principles for Trial Lawyers*, 84 UMKC L. REV. 397 (2015).

25. Oliver R. Goodenough, *Mapping Cortical Areas Associated with Legal Reasoning and Moral Intuition*, 41 JURIMETRICS 429, 430–31 (2001).

26. *Id.* at 430.

27. *Id.* at 440 (suggesting "a program of three related experiments to see whether the areas of the brain used to judge certain human behavior differs between subjects we believe to be using word-based legal analysis and subjects using moral intuition.").

28. NEUROSCIENCE AND THE LAW: BRAIN, MIND, AND THE SCALES OF JUSTICE 1–3 (Brent Garland ed., 2004). Later volumes included: LAW AND NEUROSCIENCE: CURRENT LEGAL ISSUES VOLUME 13, at 1–13 (Michael Freeman ed., 2011); LAW, MIND AND BRAIN 1–5 (Michael Freeman & Oliver R. Goodenough eds., 2009); and NEUROIMAGING IN FORENSIC PSYCHIATRY: FROM THE CLINIC TO THE COURTROOM, at xv (Joseph R. Simpson ed., 2012).

29. The articles were later published in an edited volume by Oxford University Press in LAW AND THE BRAIN, at xi (Semir Zeki & Oliver Goodenough eds., 2006).

30. Semir Zeki & Oliver Goodenough, *Law and the Brain: Introduction*, 359 PHIL. TRANSACTIONS ROYAL SOC'Y LONDON B: BIOLOGICAL SCI. 1661, 1662 (2004).

31. Joshua Greene & Jonathan Cohen, *For the Law, Neuroscience Changes Nothing and Everything*, 359 PHIL. TRANSACTIONS ROYAL SOC'Y LONDON B: BIOLOGICAL SCI. 1775, 1775–76 (2004).

many of the questions that the criminal law currently asks "will lose their grip in an age when the mechanical nature of human decision-making is fully appreciated."[32] All criminals were, in their view, "victims of neuronal circumstances,"[33] and they argued that we should jettison all retributive justifications of punishment in favor of a purely consequentialist approach.

In the same volume, Stanford neuroscientist Robert Sapolsky argued that because we know of "numerous realms in which a biological abnormality gives rise to aberrant behavior," that a human being can "know the difference between right and wrong but, for reasons of organic impairment, … not be able to do the right thing."[34] Sapolksy concluded that it would be more humane to "medicalize people into being broken cars" instead of "moralizing them into being sinners."[35]

Sapolsky's big idea—which would mean completely reformulating the criminal justice system as we know it—eventually led to the creation of the MacArthur Foundation Law and Neuroscience Project. And it was through this Project, in addition to a scholarly literature that started to blossom, that sharp debates about neuroscience and the criminal law began in earnest. A chorus of philosophers, neuroscientists, and legal scholars weighed in on questions of free will, determinism, and criminal responsibility.[36] On one side stood those such as Sapolsky, Greene, and Cohen. On the other side were scholars such as Morse and Michael Moore.[37] The dialogue spilled out into

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32. *Id.* at 1781.

33. *Id.*

34. Sapolsky, *supra* note 2, at 1793–94.

35. *Id.*

36. *See, e.g.*, A PRIMER ON CRIMINAL LAW AND NEUROSCIENCE 150–51, 153–54 (Stephen J. Morse & Adina L. Roskies eds., 2013); NEUROSCIENCE AND LEGAL RESPONSIBILITY 4–7 (Nicole A. Vincent ed., 2013); THE FUTURE OF PUNISHMENT, at xv–xxiv (Thomas A. Nadelhoffer ed., 2013); MICHAEL S. PARDO & DENNIS PATTERSON, MINDS, BRAINS, AND LAW: THE CONCEPTUAL FOUNDATIONS OF LAW AND NEUROSCIENCE 181–83 (2013); Shelley Batts, *Brain Lesions and Their Implications in Criminal Responsibility*, 27 BEHAV. SCI. & L. 261, 261 (2009); Theodore Y. Blumoff, *The Neuropsychology of Justifications and Excuses: Some Cases from Self-Defense, Duress, and Provocation*, 50 JURIMETRICS J. 391, 392–94 (2010); Deborah W. Denno, *Crime and Consciousness: Science and Involuntary Acts*, 87 MINN. L. REV. 269, 269–75 (2002); Michael S. Gazzaniga & Megan S. Steven, *Free Will in the 21st Century: A Discussion of Neuroscience and the Law*, *in* NEUROSCIENCE AND THE LAW: BRAIN, MIND, AND THE SCALES OF JUSTICE 51–53 (Brent Garland ed., 2004); Amanda C. Pustilnik, *Violence on the Brain: A Critique of Neuroscience in Criminal Law*, 44 WAKE FOREST L. REV. 183, 184–190 (2009); Richard E. Redding, *The Brain-Disordered Defendant: Neuroscience and Legal Insanity in the Twenty-First Century*, 56 AM. U. L. REV. 51, 52–54 (2006); Gideon Yaffe, *Neurological Disorder and Criminal Responsibility*, *in* THE HANDBOOK OF CLINICAL NEUROLOGY: ETHICAL AND LEGAL ISSUES IN NEUROLOGY 345 (Michael J. Aminoff et al. eds., 2013).

37. MICHAEL S. MOORE, THE NEUROSCIENCE OF VOLITIONAL EXCUSE 3–4 (2014); Michael S. Moore, *Libet's Challenge(s) to Responsible Agency*, *in* CONSCIOUS WILL AND RESPONSIBILITY 207 (Walter Sinnott-Armstrong & Lynn Nadel eds., 2011).

numerous conferences and courtrooms, and today we see an increase in neuroscientific evidence in criminal courtrooms.[38] We have also seen excellent, interdisciplinary scholarship exploring how judges and juries make their punishment decisions.[39]

We probably never will resolve some of the deepest questions about neuroscience and criminal responsibility. But we have made progress. Crucially, we have learned to speak with one another in productive ways. Through interdisciplinary conferences, organizations, and publications, we've built strong networks and foundations on which to build in the years to come.[40] At present we are seeing little change in doctrine, but strong interest in whether neuroscience can improve offender treatment and reentry.[41]

C. Need to Integrate Criminal and Civil Neurolaw Literatures

Progress was made in developing the criminal law and neuroscience dialogue over the past decade. But that dialogue was generally carried out in isolation from parallel developments in non-criminal domains. For instance, there was only limited integration between the work on responsibility with the work of scholars such as Hank Greely and Stacey Tovino. A leading figure in neuroethics as well as genetics and the law, Greely was amongst the

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38. *See, e.g.*, Paul Catley & Lisa Claydon, *The Use of Neuroscientific Evidence in the Courtroom by Those Accused of Criminal Offenses in England and Wales*, 2 J.L. & BIOSCIENCES 510, 517 (2015); Jennifer A. Chandler, *The Use of Neuroscientific Evidence in Canadian Criminal Proceedings*, 2 J.L. & BIOSCIENCES 550, 557 (2015); Nita A. Farahany, *Neuroscience and Behavioral Genetics in US Criminal Law: An Empirical Analysis*, 2 J.L. & BIOSCIENCES 485, 486 (2015); C.H. de Kogel & E.J.M.C. Westgeest, *Neuroscientific and Behavioral Genetic Information in Criminal Cases in the Netherlands*, 2 J.L. & BIOSCIENCES 580, 581–82 (2015). *But see* Matthew Ginther, *Neuroscience or Neurospeculation? Peer Commentary on Four Articles Examining the Prevalence of Neuroscience in Criminal Cases Around the World*, 3 J.L. & BIOSCIENCES 324, 324–25 (2016) (raising questions as to whether much of this evidence should be regarded as "neuroscience" evidence).

39. *See, e.g.*, MORRIS HOFFMAN, THE PUNISHER'S BRAIN: THE EVOLUTION OF JUDGE AND JURY 1–13 (Tim Kuran & Peter J. Boettke eds., 2014); Matthew R. Ginther et al., *Parsing the Behavioral and Brain Mechanisms of Third-Party Punishment*, 36 J. NEUROSCIENCE 9420, 9420–21 (2016).

40. Recent edited volumes confirm the interdisciplinary nature of the enterprise. *See, e.g.*, A PRIMER ON CRIMINAL LAW AND NEUROSCIENCE, *supra* note 36, at 150–51; PHILOSOPHICAL FOUNDATIONS OF LAW AND NEUROSCIENCE 1 (Dennis Patterson & Michael S. Pardo eds., 2016).

41. For example, in October 2016 the MacArthur Foundation Research Network on Law and Neuroscience partnered with the Oregon Health and Sciences University to present an interdisciplinary program in Portland, Oregon, entitled *Reinventing Reentry: Brain, Behavior and Better Decision-Making*.

earliest to publish thoughts on the legal implications of neuroscience.[42] Greely, in contrast to the scholarship on criminal responsibility, turned his focus primarily to neuroprediction, cognitive enhancement, and mind reading.[43] Similarly, law professor Stacey Tovino's work has challenged our field to think about a wide range of neuroscientific implications, including insurance coverage, privacy, consumer law, tort, employment law, and beyond.[44]

To be sure, there has been cross-over between the criminal and civil. The work of Adam Kolber, for instance, integrates both civil and criminal perspectives.[45] So too does the work of contracts scholar Peter Alces.[46] In addition, the influential Oxford Series in Neuroscience, Law, and Philosophy, edited by Walter Sinnott-Armstrong, has published monographs in both domains. This trend will hopefully continue, as we need to better identify the fundamental concepts and methods that undergird practice and scholarship across domains of neurolaw.

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42. *See, e.g.*, Henry T. Greely, *Law and the Revolution in Neuroscience: An Early Look at the Field*, 42 AKRON L. REV. 687, 687–89 (2009) [hereinafter Greely, *Law and the Revolution in Neuroscience*]; Henry T. Greely, *Prediction, Litigation, Privacy, and Property: Some Possible Legal and Social Implications of Advances in Neuroscience*, *in* NEUROSCIENCE AND THE LAW: BRAIN, MIND, AND THE SCALES OF JUSTICE 114–15 (Brent Garland ed., 2004); Henry T. Greely, *The Social Effects of Advances in Neuroscience: Legal Problems, Legal Perspectives*, *in* NEUROETHICS: DEFINING THE ISSUES IN THEORY, PRACTICE, AND POLICY 245–46 (Judy Illes ed., 2006) [hereinafter Greely, *Social Effects*].

43. Greely, *Social Effects*, *supra* note 42, at 246, 249, 255. Greely does address criminal responsibility. *See* Greely, *Law and the Revolution in Neuroscience*, *supra* note 42, at 699 (suggesting that we will still treat offenders as if they have free will generally, but "neuroscience may well affect our sense of criminal (and civil) responsibility in some cases."). When Greely did turn his attention to the criminal law, he suggested that neuroscience would play a minimal role in criminal responsibility, and that "an overly strong focus on responsibility . . . [might] draw attention away from more important and troubling areas." Henry T. Greely, *Neuroscience and Criminal Justice: Not Responsibility but Treatment*, 56 U. KAN. L. REV. 1103, 1103–04 (2008) (focusing on treatment, and reviewing how neuroscience might affect the way we treat offenders in our justice system).

44. Stacey A. Tovino, *Functional Neuroimaging Information: A Case for Neuro Exceptionalism?*, 34 FLA. ST. U. L. REV. 415, 415–19 (2007); Stacey A. Tovino, *Imaging Body Structure and Mapping Brain Function: A Historical Approach*, 33 AM. J.L. & MED. 193, 193–95 (2007); Stacey A. Tovino, *Neuroimaging Research into Disorders of Consciousness: Moral Imperative or Ethical and Legal Failure?*, 13 VA. J.L. & TECH. 2, 2–7 (2008); Stacey A. Tovino, *Neuroscience and Health Law: An Integrative Approach?*, 42 AKRON L. REV. 469, 469–74 (2009); Stacey A. Tovino, *The Impact of Neuroscience on Health Law*, 1 NEUROETHICS 101, 101–03 (2008).

45. Adam Kolber, *Legal Implications of Memory-Dampening*, *in* LAW, MIND AND BRAIN 215, 218–33 (Michael Freeman & Oliver R. Goodenough eds., 2009); Adam J. Kolber, *The Subjective Experience of Punishment*, 109 COLUM. L. REV. 182, 183–87 (2009).

46. *See, e.g.*, PETER A. ALCES, THE NORMATIVE INTERSECTION OF LAW AND NEUROSCIENCE (forthcoming).

D. The fMRI Fetish

A limitation in the first wave of neurolaw scholarship is its fMRI fetish. By "fetish" I do not mean that scholars uniformly believed fMRI to have magic powers. Indeed, much of the literature has gone out of its way to *critique* fMRI.[47] Rather, I mean fetish as a fixation. Specifically, for much of the literature to date, "neuroscientific evidence" has been equated with fMRI. This is problematic. As awesome as fMRI is, it is only one of many ways in which neuroscience is uncovering truths about our brains. Neurolaw tethered to a single technology fails to capture its full potential.

To be clear, mine is not a critique of fMRI, nor of fMRI over-claim. The best imagers are upfront about the limits, and future possibilities, of their techniques.[48] My critique is of legal scholars (including myself) for focusing so exclusively on fMRI that a reader would think that neuroscience is nothing but brain scans. We need to remember that the vast majority of neuroscientists do not use fMRI. Why? Because they are busy with animal models, molecular and cellular work, lesion studies, and a myriad of tools other than imaging. Looking back at Law and Neuroscience 1.0, one will not find sufficient engagement with most of these other types of neuroscientific investigation.

E. Blank Slate Neurolaw

While fMRI is over-represented in the first wave of neurolaw scholarship, under-represented are extended discussions about the evolutionary origins of our brains. This is not to say that those perspectives are entirely absent. For instance, Owen Jones, who pioneered evolutionary analysis in the law,[49] directs the MacArthur Foundation Research Network on Law and Neuroscience. But much of neurolaw scholarship seems to overlook what Jones has emphasized: "Evolutionary processes (such as natural selection and

47. *See, e.g.*, Teneille Brown & Emily Murphy, *Through a Scanner Darkly: Functional Neuroimaging as Evidence of a Criminal Defendant's Past Mental States*, 62 STAN. L. REV. 1119, 1174–1202 (2010); Owen D. Jones et al., *Brain Imaging for Legal Thinkers: A Guide for the Perplexed*, 2009 STAN. TECH. L. REV. 5, 82–84.

48. *See, e.g.*, Russell A. Poldrack et al., *Scanning the Horizon: Challenges and Solutions for Neuroimaging Research*, BIORXIV (Aug. 1, 2016), http://biorxiv.org/content/early/2016/08/01/059188.full.pdf+html.

49. *See, e.g.*, Owen D. Jones, *Evolutionary Analysis in Law: An Introduction and Application to Child Abuse*, 75 N.C. L. REV. 1117, 1120–26 (1997).

sexual selection)—together with environmental and physical inputs—built the brains that yield behaviors."[50]

Much of the time, the lack of evolutionary perspective is probably harmless. But without evolutionary perspectives and genetics, we risk drifting into "blank slate neurolaw." With a nod to psychologist Steven Pinker's book of a similar title,[51] I use the term blank slate neurolaw to refer to a framing of the brain that only emphasizes our ability to change the way our minds work. The most blatant portrayals of blank slate neuroscience appear in the self-help literature. Those books promise that you can change your brain to be happier, sexier, and smarter.

In the context of neurolaw, I have seen a similar (albeit not as dramatic) sentiment. Consider one brief example about the education of law students and the buzzword "neuroplasticity." In one law review article, the author wrote:

> Brain health literacy or neuro-intelligence ("NQ") is a critical competency for lawyers, judges, law faculty, and law students because lawyering is a cognitive profession. The optimistic phenomenon of plasticity in the lawyer brain and genes demonstrates that personal choices, environments, and cultures shape the development of the lawyer's brain throughout life.[52]

I am not entirely sure what the phrase "optimistic phenomenon" means, nor why it is applicable to plasticity, but I am sure that the author's message is this: you *can* change your brain. Indeed, a little later in the article we are explicitly told that: "Neuroplasticity, neurogenesis, and epigenetics ensure there is *always* a path to strengthen the lawyer brain."[53] Another recent article said virtually the same thing about legal education: "our evolving understanding of brain growth and neuroplasticity suggests that change in cognitive structures is possible even in the 'mature adult,' a characterization that describes the majority of law students."[54]

The problem with these renditions of brain science is that they suggest the law student brain is a blank canvas onto which law school programming can paint. They fail to recognize that by the time a student enrolls in law school, certain types of information processing may be very impermeable to change.

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50. Owen D. Jones, *Evolutionary Analysis in Law: Some Objections Considered*, 67 BROOK. L. REV. 207, 211 (2001).

51. STEVEN PINKER, THE BLANK SLATE: THE MODERN DENIAL OF HUMAN NATURE (2002).

52. Debra S. Austin, *Drink Like a Lawyer: The Neuroscience of Substance Use and Its Impact on Cognitive Wellness*, 15 NEV. L.J. 826, 829 (2015).

53. *Id.* at 871 (emphasis added).

54. Ann Mallatt Killenbeck, *Ferguson, Fisher, and the Future: Diversity and Inclusion as a Remedy for Implicit Racial Bias*, 42 J.C. & U.L. 59, 113 (2016).

I am not suggesting that behavior cannot be changed in law school. Surely it can, and does. But whether a particular law school intervention works must be evaluated empirically, not with a convenient cite to brain science. The science of neuroplasticity should not be used to support blanket claims that social and educational interventions can work for everyone. That's blank slate neurolaw, and it ought to be avoided.

F. Minding the Gap

There is a strong consensus amongst those who think carefully about the topic that we need to be cautious in the implications we draw from present neuroscientific work. Judy Edersheim and Bruce Price, co-directors of the Center for Law, Brain and Behavior at Massachusetts General Hospital and Harvard Medical School, writing with Harvard psychiatrist Jordan Smoller, have summed it up well:

> We are making remarkable strides in identifying specific functional brain networks and the genetic and environmental causes for disruptions in these networks. However, until we can make well-founded, scientifically sound and legally relevant links between genes, brains and behaviors, judges, juries and the public should be wary of neuroscience in the courtroom.[55]

Scholarly hesitance such as this is integral for the careful development of the field.

But going slow is not so great for practitioners who want to know what neuroscience can do for them *now*. There is thus a gap between the practical tools that lawyers and judges want, and the more basic, speculative science that currently exists.

The gap can be handled in one of two ways: supply-side and demand-side. Supply-side approaches, which I strongly favor, look at the supply of science and are upfront about the limits of current knowledge. This approach recognizes the gap, without trying to prematurely cross it. For instance, in the Education and Outreach activities sponsored by the MacArthur Foundation Research Network on Law and Neuroscience we preach the importance of limits and cautions.[56] This is scientifically sound, but frustrating for

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55. Judith G. Edersheim et al., *'Your Honor, My Genes Made Me Do It'*, WALL STREET J., http://www.wsj.com/articles/SB10000872396390444592404578030652157630958 (last updated Oct. 21, 2012, 6:26 PM).

56. These activities have included conferences to introduce judges to neuroscience, as well as introductory materials for judges and attorneys. Programs are available at *Education and*

practitioners. On more than one occasion, I have heard from attendees at these programs that they wished there would have been more practical guidance.

This leads to the second way of gap-filling: giving in to demand. If practitioners want tools, one can package neuroscience in such a way that it provides those tools. As an example, consider this event advertisement, which was marketed to psychotherapists:[57]

> We've all been dazzled by the findings of neuroscience . . . . But for many of us, the question remains—How do I use these findings to help my clients in concrete and practical ways? To answer your questions about practical applications of brain science, we invited leading brain science experts to be part of our online video course—Brain Science Matters. This series is designed to enhance your clinical skills, speed up healing, and transform your clients' lives by translating complex concepts like neuroplasticity and brain integration into real world therapeutic procedures.

For a therapist looking for an edge, the promise of such a program is enticing (even at a cost of $179). The allure of brain science may make the program more attractive than it would otherwise be.[58] Yet these types of programs are exactly what neurolaw should *not* emulate. Why? Because neuroscience to date simply does not allow for such claims.

In the domain of law and neuroscience, a variety of Continuing Legal Education (CLE) programs have made claims that neuroscience will provide concrete ways to make attendees better lawyers.[59] One scholar has even suggested that an article on "neural self-hacking" is a "groundbreaking synthesis on the neuroscience of how to achieve optimal cognitive fitness is

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Outreach, MACARTHUR FOUND. RES. NETWORK ON L. & NEUROSCIENCE, http://www.lawneuro.org/outreach.php (last visited Jan. 16, 2017).

57. *Transform your Clients' Lives with Brain-Based Change that Lasts*, PSYCHOTHERAPY NETWORKER, https://www2.psychotherapynetworker.org/webcasts/brain-science-web-series (last visited Jan. 4, 2017).

58. This speculation is fueled by research finding that neuroscience information may make psychological information more appealing. Diego Fernandez-Duque et al., *Superfluous Neuroscience Information Makes Explanations of Psychological Phenomena More Appealing*, 27 J. COGNITIVE NEUROSCIENCE 926, 926–28 (2015).

59. *See, e.g.*, Scott A. Moriarity & Sarah Bridges, *Address for the Good Data, Bad Decisions: What Neuroscience Teaches Us About Legal Advocacy*, MINN. CLE (Apr. 14, 2016), https://www.minncle.org/SeminarDetail.aspx?ID=1211511601 ("As our knowledge of the brain and decision making increases, we have more tools at our disposal for effective legal advocacy."); Kimberly Papillon, *Neuroscience Decisions and the Law CLE*, WASH. ST. B. ASS'N (June 23, 2015) (sharing "what the latest brain-imaging and decision-making studies tell us about the ways we assess and react to one another—how we determine veracity, intelligence, threat, and competence in a diverse society—and the implications for the many decisions lawyers make every day").

a must-read for all law students, law professors, and lawyers."[60] While I think there is great value in behavioral science to provide a variety of tools, I am generally dubious that—at present—understanding how that psychology is physically instantiated in neural tissue will provide much value added for legal practice. To take just one example, lawyers in one CLE program were asked to pay $299 for a day-long program to learn what "the latest brain-imaging and decision-making studies tell us about the ways we assess and react to one another—how we determine veracity, intelligence, threat, and competence in a diverse society—and the implications for the many decisions lawyers make every day."[61] Is there really *neuroscience* (and not just behavioral) research that can meaningfully guide the daily decisions of attorneys? Maybe. But I am skeptical.

In part this skepticism is generated by the challenges I have seen in the related field of educational neuroscience.[62] Educational neuroscience has been a field filled with controversy.[63] Yet it is also a field filled with books, articles, and powerful advocates.[64] Notably, in both the Bill Clinton and George W. Bush administrations, the White House convened scholars in education and neuroscience to develop policy in the area.

In one sense, educational neuroscience may seem a model for neurolaw. After all, the field has generated significant funding, and who would not want to meet in the White House (twice!). But I view educational neuroscience as a cautionary tale for law and neuroscience. The reason is that educational neuroscience has not solved a single big problem in education. Even today, two decades after those initial White House meetings, neuroscience has

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60. Debra S. Austin, *Killing Them Softly: Neuroscience Reveals How Brain Cells Die from Law School Stress and How Neural Self-Hacking Can Optimize Cognitive Performance*, 59 LOY. L. REV. 791, 799 (2013).

61. Papillon, *supra* note 59.

62. *See* John T. Bruer, *Research Base for Improved Classroom Learning: Brain or Behavior?*, BROOKINGS (Dec. 17, 2015), http://www.brookings.edu/research/reports/2015/12/17-research-base-improved-learning-bruer [hereinafter Bruer, *Brain or Behavior*]; *see also* John T. Bruer, *Windows of Opportunity: Their Seductive Appeal*, BROOKINGS (Oct. 22, 2015), http://www.brookings.edu/research/papers/2015/10/22-childhood-education-neuroscience-window-opportunity-bruer. *See generally* JOHN T. BRUER, THE MYTH OF THE FIRST THREE YEARS 13–14, 16, 43–44, 158–59 (1999); NEUROSCIENCE IN EDUCATION: THE GOOD, THE BAD, AND THE UGLY 128 (Sergio Della Sala & Mike Anderson eds., 2012); John T. Bruer, *Education and the Brain: A Bridge Too Far*, 26 EDUC. RESEARCHER 4, 4–5 (1997).

63. Cayce J. Hook & Martha J. Farah, *Neuroscience for Educators: What are They Seeking, and What are They Finding?*, 6 NEUROETHICS 331, 332 (2013) ("Neuroeducation has been a controversial field since its beginnings in the 1990s.").

64. *Id.* ("Despite criticism from without and within the field, neuroeducation has flourished. An Amazon.com search for 'brain education' returns over 2,000 books, of which nearly 900 were published within the last five years.").

relatively little to offer the bulk of education practice.[65] As one critical psychologist argued in 2016, "[e]ducational neuroscience only tells us what we know already or gives us information that is irrelevant. The problems faced by classroom teachers dealing with learning difficulties can only be diagnosed and addressed through behavioural [sic] methods."[66]

Moreover, research on what educators want suggests that they use neuroscience not to directly change classroom practice, but rather "to maintain patience, optimism and professionalism with their students, to increase their credibility with colleagues and parents, and to reinforce their sense of education as a profession concerned with shaping students' brain development."[67] Educational neuroscience in this sense has been smart. Promising concrete, practical lessons from neuroscience is consumer-savvy. It is filling a gap and making educators feel good about their work. But it has not delivered revolutionary insights.

To its great credit, Law and Neuroscience 1.0 has not (yet) gone down this road. With the exception of a few CLEs and some over-zealous media headlines, the bulk of scholarship and debate has been concerned with getting this right—not getting this done quickly. But increasingly, I suspect, there will be greater pressure on our field to move more in the direction of educational neuroscience, to prove our worth to the legal profession with splashy conferences and quirky slogans like "tools you can use." We should resist the temptation to cash in.

II. THE LANDSCAPE OF NEUROLAW POSSIBILITY

I concluded the previous Part by suggesting that we must resist the temptation to over-sell neuroscience. I begin this Part by conveying a

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65. Bruer, *Brain or Behavior*, *supra* note 62 ("Comparative analysis of the education research literature versus the educational neuroscience literature suggests that education research, grounded in the behavioral and cognitive sciences, is currently the better research base for instructional design, particularly if our goal is to improve educational outcomes in the near to intermediate future.").

66. *Is Educational Neuroscience a Waste of Money?*, SCI. 2.0 (Mar. 9, 2016, 4:11 PM), http://www.science20.com/news_articles/is_educational_neuroscience_a_waste_of_money-167631; *see, e.g.*, HILARY ROSE & STEVEN ROSE, CAN NEUROSCIENCE CHANGE OUR MINDS? 106 (2016) (criticizing the over-emphasis of neuroscience in education policy); Jeffrey S. Bowers, *The Practical and Principled Problems with Educational Neuroscience*, 123 PSYCHOL. REV. 600, 609 (2016).

67. Hook & Farah, *supra* note 63, at 339–40. Educators also want "intellectual stimulation, new ways of thinking about their students and their own work, and new ways of explaining and justifying their educational practices within the framework of neuroscience." *Id.* at 339.

complementary message: we must also seek out those areas in which the neuroscience offers—now or in the near future—something tangible for law.

I offer in the sections that follow fifteen different possibilities, each of which lay before us here-and-now issues. Given space limitations, I do not go in-depth on any particular topic, and I offer just a brief vignette on some. Because they have been discussed elsewhere and are already on-going, I also do not discuss criminal justice (where we can still do much more), pain, and brain injury. On pain, Amanda Pustilnik is leading a multidisciplinary effort to investigate the legal implications of the neuroscience of pain.[68] On brain injury there is a rich history of collaboration on the civil side between attorneys and neuropsychologists.[69] Emphasizing that the list below is only a beginning, I turn now to possibilities for neurolaw 2.0.

A. Fifteen Possibilities

1. Regulation of Mobile Consumer Neurotechnology

A consequence of the fMRI fetish discussed previously is that the field of neurolaw has been slow to recognize a variety of developments in mobile neurotechnology. The advent of smart phones, combined with advances in both brain reading and brain manipulation, has led to a great number of new products in the past ten years (and especially the past five.) This includes the development of wearable electroencephalography (EEG) technology, and consumer friendly brain stimulation devices.

In the realm of wearable EEG, consumers can use their smart phones, attached wirelessly to an EEG device placed on their head, to get real-time electrical brain activity data in order to modulate their thoughts. EEG, originally discovered in 1929, is a method of measuring electrical activity produced by the brain.[70] Technology that is currently being sold to consumers includes the EEG-based Muse headband (promising to help you calm

68. Amanda C. Pustilnik, *Pain as Fact and Heuristic: How Pain Neuroimaging Illuminates Moral Dimensions of Law*, 97 CORNELL L. REV. 801, 802–07 (2012); David Seminowicz et al., *Panel 1: Legal and Neuroscientific Perspectives on Chronic Pain*, 18 J. HEALTH CARE L. & POL'Y 207, 211–12 (2015). This work is based at the Center for Law, Brain and Behavior at Harvard Medical School. *Pain & the Neuroscience of Suffering*, MASS. GEN. HOSP. CTR. FOR L. BRAIN & BEHAV., http://clbb.mgh.harvard.edu/pain/ (last visited Jan. 4, 2017).

69. *See* Shen, *supra* note 4; *see also* Taylor, *supra* note 24, at 398–400.

70. S.J.M. Smith, *EEG in the Diagnosis, Classification, and Management of Patients with Epilepsy*, 76 J. NEUROLOGY NEUROSURGERY & PSYCHIATRY ii2, ii2 (2005).

down);[71] headsets by Neurosky (for education and wellness)[72]; and the Emotiv EPOC headset (for gaming and research).[73] In addition, a device called UMood tracks consumers' brainwaves as they shop, with the intention of understanding and then influencing consumer purchasing decisions.[74] The military is using EEG-based sensors to monitor soldiers' brain activity over the course of the day.[75] These mobile neurotechnologies are here-and-now issues, ripe for legal and ethical analysis.[76] Much additional work is needed.[77]

Consumer-friendly brain stimulation devices also have developed. Historically, neuroscientific evaluation required a trip to a hospital or research facility. But today consumers can purchase a transcranial direct current stimulation (tDCS) device to alter mood and potentially treat mental disorders. tDCS sends low voltage electrical currents into targeted areas of the brain.[78] For instance, studies have examined the use of tDCS to treat depression.[79] In the current marketplace, the Thync company markets to users that tDCS can de-stress and boost their energy.[80]

Mobile neurotechnology such as this offers both promise and peril. On one hand, the technology may lead to improved mental health and enjoyment of

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71. MUSE, http://www.choosemuse.com/ (last visited Jan. 4, 2017).

72. *MindWave*, NERUOSKY, http://store.neurosky.com/pages/mindwave (last visited Jan. 4, 2017).

73. *EMOTIV Epoc+*, EMOTIV, https://www.emotiv.com/epoc/ (last visited Jan. 4, 2017).

74. Dinushi Dias, *How Consumer Neuroscience Is Transforming How We Shop*, SMARTCOMPANY (Apr. 20, 2016), http://www.smartcompany.com.au/industries/retail/67556-how-consumer-neuroscience-is-transforming-how-we-shop/.

75. *US Army Researchers Study Neuroscience to Predict Soldier Activity*, ARMY-TECHNOLOGY.COM (Aug. 4, 2016), http://www.army-technology.com/news/newsus-army-researchers-study-neuroscience-to-predict-soldier-activity-4969662.

76. Indeed, I am a member of the Center for Responsible Brainwave Technologies, which has just started to explore some of these issues. CEREB: CTR. FOR RESPONSIBLE BRAINWAIVE TECH., http://www.responsiblebraintech.org/ (last visited Jan. 4, 2017).

77. *See* Anna Wexler, *A Pragmatic Analysis of the Regulation of Consumer Transcranial Direct Current Stimulation (TDCS) Devices in the United States*, 2 J.L. & BIOSCIENCES 669, 671–73 (2015).

78. Felipe Fregni & Alvaro Pascual-Leone, *Technology Insight: Noninvasive Brain Stimulation in Neurology—Perspectives on the Therapeutic Potential of rTMS and tDCS*, BERENSON-ALLEN CTR. FOR NONINVASIVE BRAIN STIMULATION (Apr. 13, 2007), http://www.tmslab.org/publications/111.pdf.

79. U.G. Kalu et al., *Transcranial Direct Current Stimulation in the Treatment of Major Depression: A Meta-Analysis*, 42 PSYCHOL. MED. 1791, 1791–92 (2012).

80. *The Thync Wants to Stimulate Your Brain and Help You Recharge*, STORY, http://thisisstory.com/the-thync-wants-to-stimulate-your-brain-and-help-you-recharge/ (last visited Jan. 5, 2017) ("Thync uses low-energy waveforms to safely and comfortably stimulate nerves on your head and face. These nerves signal specific areas of the brain that cause your body to relax or energize."); *Thync: Company Profile*, INNOVATION ENTER., https://theinnovationenterprise.com/summits/wearable-tech-in-sport-summit-san-francisco-2016/sponsors/7496 (last visited Jan. 5, 2017).

life. On the other hand, the technology (and the data it collects) raises important questions concerning regulation, safety, efficacy, and privacy. While academic dialogue about some of these questions has begun,[81] the questions above have not been sufficiently explored. Neurolaw 2.0 has an enticing menu of questions to address in this arena, including:

- *Efficacy*: Does the technology provide the benefits it promises, and what is known about variation in efficacy across individuals?
- *Safety*: What are the known side effects, and how do they compare to other technologies?
- *Regulation*: How, if at all, should the FDA regulate this technology? In what ways is this distinguishable from, or analogous to, existing technologies (some of which are under FDA oversight and some of which are not)?
- *Privacy*: How is brain data being stored and used by the companies processing the data for consumers? What levels of access do users have to their own data?
- *Legal*: The law regulates many types of brain modulation, for instance making it illegal to drive in certain brain states. In what ways should law account for brain changes brought on by neurofeedback and neurostimulation?
- *Ethical*: Does neurostimulation deserve special ethical attention as compared to other, more indirect, ways of modulating mental activity?

2. Concussions in Youth and Professional Sports

In just the past ten years, all fifty states have enacted statutes related to youth sports concussions.[82] Following this "first wave" of concussion

81. *See, e.g.*, F. Fregni et al., *Regulatory Considerations for the Clinical and Research Use of Transcranial Direct Current Stimulation (tDCS): Review and Recommendations from an Expert Panel*, 32 CLINICAL RES. & REG. AFF. 22, 22–23 (2015).

82. Christine M. Baugh et al., *Requiring Athletes to Acknowledge Receipt of Concussion-Related Information and Responsibility to Report Symptoms: A Study of the Prevalence, Variation, and Possible Improvements*, 42 J. L. MED. & ETHICS 297, 299 (2014); Kerri McGowan Lowrey, *State Laws Addressing Youth Sports-Related Traumatic Brain Injury and the Future of*

legislation, states are beginning to revisit the issue to determine what works, what does not, and what additional reforms are needed.[83] Although not always cited as within the "neurolaw" domain, concussion related lawsuits (most prominently the class action National Football League lawsuit settled in 2016) have emerged,[84] and legal scholars have been active in debates on traumatic brain injury ("TBI") in sports.[85]

Legal and policy scholars have important roles to play in shaping this next wave of concussion policy. In particular, we know little about the quality of information and effectiveness of treatment provided to student-athletes, including potential disparities of treatment across ages, sports, or regions. Nor do we know if students are receiving the care they need to succeed in the classroom (i.e., "Return to Learn") after concussion incidents. Unknowns like this make it difficult to assess legal exposure for school districts and optimal regulatory structures for states to employ.[86]

Moreover, the role of neuroscience in the assessment and treatment of TBI, both in and beyond the sports context, is developing rapidly.[87] This raises questions about the reasonable standard of care, efficacy of reforms, and more. Legal scholars, working with a variety of other disciplines, are well positioned to lead in this area. Statutes are being re-evaluated, policies being implemented, and law suits being filed.[88]

Concussion Law and Policy, 10 J. BUS. & TECH. L. 61, 63 (2015) ("As of April 2014, every state and the District of Columbia, has enacted a law that addresses youth sports concussion.").

83. Kerri McGowan Lowrey, *Revising the Game Plan: Primary Prevention, Early Detection, and the Future of Concussion Laws*, NETWORK FOR PUB. HEALTH L. (July 21, 2014, 2:57 PM), https://www.networkforphl.org/the_network_blog/2014/07/21/474/revising_the_game_plan_primary_prevention_early_detection_and_the_future_of_concussion_laws ("Now that many of these laws have been in effect for a few years, legislatures are revisiting them and making changes according to developments in the field.").

84. *In re* Nat'l Football League Players Concussion Injury Litig., 821 F.3d 410, 421–22 (3d Cir. 2016); *In re* Nat'l Football League Players' Concussion Injury Litig., 961 F. Supp. 2d 708, 712–13 (E.D. Pa. 2014).

85. *See, e.g.*, Tracey B. Carter, *From Youth Sports to Collegiate Athletics to Professional Leagues: Is There Really "Informed Consent" by Athletes Regarding Sports-Related Concussions?*, 84 UMKC L. REV. 331, 331 (2015); Dionne L. Koller, *Putting Public Law into "Private" Sport*, 43 PEPP. L. REV. 681, 711–13 (2016).

86. As a first step to address this issue in Minnesota in 2015, I drafted legislation that was subsequently introduced in the Minnesota House and Senate. *See* H.F. 3655, 89th Leg., 2d Sess. (Minn. 2015); S.F. 3144, 89th Leg., 2d Sess. (Minn. 2015).

87. *See, e.g.*, *Traumatic Brain Injury: Hope Through Research*, NAT'L INST. NEUROLOGICAL DISORDERS & STROKE, https://www.ninds.nih.gov/Disorders/Patient-Caregiver-Education/Hope-Through-Research/Traumatic-Brain-Injury-Hope-Through (last visited Jan. 16, 2017).

88. *In re* Nat. Hockey League Players' Concussion Injury Litig., No. MDL 14-2551 SRN, 2015 WL 1334027 (D. Minn. Mar. 25, 2015); Owen Blood & John-Michael Porretta, *Litigating*

3. Legal Implications of Early-Onset Dementia Detection

While much attention in Law and Neuroscience 1.0 concerned juvenile development, Law and Neuroscience 2.0 would do well to look at the other end of the age spectrum as well. In 2010, an estimated 4.7 million Americans aged 65 and older suffered from Alzheimer's disease ("AD"), and by 2050 this number is projected to reach 13.8 million.[89] With no cure for Alzheimer's, there is a push toward using neuroimaging such as Positron Emission Tomography (PET) to identify changes in the brain that might indicate a higher-than-normal risk for developing dementia (and thus allow for behavioral and pharmacological interventions earlier.)[90] At present, the medical consensus is that this is not ready for clinical use,[91] but it's being used in research contexts and it seems reasonable to expect that—given consumer demands—we will see some version of early detection methodology arriving in clinics in the not too distant future.

Law, especially regulatory, insurance, and related bodies of health law, are already (and will continue to) play important roles here. For instance, the Food and Drug Administration governs the approval of methods—such as the use of PET brain scans—to detect Alzheimer's. In 2012 and again in 2013, the FDA approved drugs, in conjunction with PET imaging, for evaluation of Alzheimer's.[92] Yet, in 2015 the FDA also intervened to stop the company Taumark from promoting an unapproved drug for dementia detection.[93]

Sports Brain Injuries: The New Ball Game, 104 ILL. B.J. 28 (2016); Betsy J. Grey & Gary E. Marchant, *Biomarkers, Concussions, and the Duty of Care*, 2015 MICH. ST. L. REV. 1911.

89. Liesi E. Hebert et al., *Alzheimer's Disease in the United States (2010-2050) Estimated Using the 2010 Census*, 80 NEUROLOGY 1778, 1778 (2013).

90. J.T. O'Brien & P. Scheltens, *Clinical Use of Neuroimaging in Dementia: An International Perspective*, 23 INT'L PSYCHOGERIATRICS S3, S3–S5 (Supp. II 2011).

91. MARILYN ALBERT ET AL., ALZHEIMER'S ASS'N, THE USE OF MRI AND PET FOR CLINICAL DIAGNOSIS OF DEMENTIA AND INVESTIGATION OF COGNITIVE IMPAIRMENT: A CONSENSUS REPORT 2 (2005), https://www.alz.org/national/documents/imaging_consensus_report.pdf.

92. Press Release, FDA, FDA Approves Imaging Drug Amyvid (Apr. 10, 2012), http://www.fda.gov/NewsEvents/Newsroom/PressAnnouncements/ucm299678.htm (approving "Amyvid (Florbetapir F 18 Injection) a drug for Positron Emission Tomography (PET) imaging of the brain in adults who are being evaluated for Alzheimer's Disease (AD) and other causes of cognitive decline."); Press Release, FDA, FDA Approves Second Brain Imaging Drug to Help Evaluate Patients for Alzheimer's Disease, Dementia (Oct. 25, 2013), http://www.fda.gov/newsevents/newsroom/pressannouncements/ucm372261.htm (approving "Vizamyl (flutemetamol F 18 injection), a radioactive diagnostic drug for use with positron emission tomography (PET) imaging of the brain in adults being evaluated for Alzheimer's disease (AD) and dementia.").

93. Alan Zaermbo, *FDA Forces UCLA Researchers to Stop Touting Experimental Dementia Scan*, L.A. TIMES (Apr. 10, 2015), http://www.latimes.com/science/sciencenow/la-sci-sn-brain-scan-warning-taumark-20150410-story.html.

The attendant legal and ethical questions to these developments are numerous and challenging. For instance, as the science progresses, does a doctor have a legal duty to inform some (or all) patients of certain ages about the procedures. How will insurance coverage work? If a result is returned that suggests a higher likelihood of dementia, is "being at heightened risk for dementia" a legally-relevant brain state? That is, can that otherwise healthy individual receive disability benefits at the first sign of brain change? Can the individual withhold this information from her insurer? What are the insurer's obligations? There are an additional set of questions about the admissibility of the brain imaging evidence in legal disputes over capacity and related issues.

The crux of the challenge is that most law (and to date, most medicine) doesn't respond until there is a change in observed behavior. That is, we don't typically know that someone has dementia until they repeatedly show behavioral manifestations.[94] Early diagnosis—based on changes in brain tissue and not just static factors such as age—complicates things. An individual appears normal to her friends, and feels normal herself. But if her brain has changed (and is changing), is she still "normal" in the eyes of the law? Our lab is starting to explore these types of questions, and we have found the area to be extremely ripe for investigation.[95]

4. Brain Biomarkers and Brain-Based Prediction

Brain-based biomarkers are developing not only in the context of dementia, but elsewhere in medicine. There are tremendous legal and ethical questions that follow.[96] Part of the concern is the use of bioprediction for socially deviant (i.e., criminal) behavior.[97] But also of concern is the clinical use of biomarkers for the general population.[98]

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94. Pam Belluck, *Personality Change May Be Early Sign of Dementia, Experts Say*, N.Y. TIMES (July 24, 2016), http://www.nytimes.com/2016/07/26/health/alzheimers-checklist-mild-behavioral-impairment.html.

95. Joshua Preson et al., *The Legal Implications of Detecting Alzheimer's Disease Earlier*, 18 AMA J. ETHICS 1207 (2016).

96. *See* Ilina Singh & Walter P. Sinnott-Armstrong, *Introduction: Deviance, Classification, and Bioprediction*, *in* BIOPREDICTION, BIOMARKERS, AND BAD BEHAVIOR 11, 11 (Ilina Singh et al. eds., 2014) (noting that "[m]uch scientific work remains to be done in the area of predictive biomarkers, but this is not reason to be complacent about its impact on and translation into the public domain").

97. Paul Root Wolpe, *Rethinking the Implications of Discovering Biomarkers for Biologically Based Criminality*, *in* BIOPREDICTION, BIOMARKERS, AND BAD BEHAVIOR 118, 118 (Ilina Singh et al. eds., 2014).

98. *See* Singh & Sinnott-Armstrong, *supra* note 96.

At present, no brain biomarkers are in regular use for psychiatric disorders. But some are optimistic about both present and near-future abilities.[99] For instance, Vince Calhoun and Mohammad Arbabshirani "believe that a combination of MRI-based neuroimaging biomarkers, along with other biomarkers from modalities such as EEG and MEG and genetics, can provide a robust framework for diagnosis and prognosis of various mental disorders with high accuracy in a reasonable time."[100]

Psychiatrist Matthew Baum's recent book on the neuroethics of biomarkers is an important contribution to this dialogue.[101] Baum points out that "biomarker discovery and assembly into bio-actuarial tools are poised to proceed at an unprecedented pace."[102] The ethical and legal questions will also increase. For instance, Baum raises the policy challenge of prioritization.[103] Should we use bio-actuarial tools to improve the ways that we distribute scarce resources? Baum acknowledges that his book "raises many more questions than it answers,"[104] and this is the sign of an area ripe for further research. If we follow Baum's suggestion to move away from categorical and toward probabilistic thinking in law, this will require intense collaboration with scholars in insurance, risk, and related fields.

5. Admissibility of Novel Neuroscientific Evidence

Law and Neuroscience 1.0 has given us an excellent foundation with which to think both conceptually[105] and empirically[106] about the introduction

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99. Alex Fornito & Edward T. Bullmore, *Does fMRI Have a Role in Personalized Health Care for Psychiatric Patients*, *in* INTEGRATIVE NEUROSCIENCE AND PERSONALIZED MEDICINE 55 (Evian Gordon & Stephen H. Koslow eds., 2011) (suggesting that "recent computational and methodological advances provide a sufficient basis for cautious optimism concerning the future clinical applicability of fMRI").

100. Vince D. Calhoun & Mohammad R. Arbabshirani, *Neuroimaging-Based Automatic Classification of Schizophrenia*, *in* BIOPREDICTION, BIOMARKERS, AND BAD BEHAVIOR 224 (Ilina Singh et al. eds., 2014).

101. MATTHEW L. BAUM, THE NEUROETHICS OF BIOMARKERS (2016).

102. *Id.* at 10–11.

103. *Id.* at 6–7.

104. *Id.* at 166.

105. *See, e.g.*, Leonard Berlin, *Neuroimaging, Expert Witnesses, and Ethics: Convergence and Conflict in the Courtroom*, 5 AJOB NEUROSCIENCE 3, 3 (2014); David L. Faigman et al., *Group to Individual (G2I) Inference in Scientific Expert Testimony*, 81 U. CHI. L. REV. 417, 419–21 (2014); Lyn M. Gaudet et al., *Functional Magnetic Resonance Imaging in Court*, 5 AJOB NEUROSCIENCE 43, 43 (2014); Jane C. Moriarty, *Visions of Deception: Neuroimages and the Search for Truth*, 42 AKRON L. REV. 739, 739–46 (2009); Walter Sinnott-Armstrong et al., *Brain Images as Legal Evidence*, 5 EPISTEME 359, 359–72 (2008).

106. *See, e.g.*, Catley & Claydon, *supra* note 38, at 543–44; Chandler, *supra* note 38; Farahany, *supra* note 38; Kogel & Westgeest, *supra* note 38. *But see* Ginther, *supra* note 38

of neuroscientific evidence in the courtroom. Some empirical studies have found that the "seductive allure" of neuroscientific explanations might be unduly persuasive.[107] Research also suggests that lay people find neuroscientific explanations particularly persuasive,[108] and that neuroscientific explanations can change lay determinations of "bodily injury."[109] In addition, an experimental study using state court judges as subjects concluded that judges significantly reduced their sentences for psychopaths when provided with a neuroscientific explanation for the psychopath's behavior.[110] But running counter to these studies are reported experiments that have found null,[111] or contingent effects.[112] Recent commentary has suggested that perhaps concerns over the seductive allure are misplaced.[113] On-going work in my own lab suggests that the effect of neuroscientific evidence is highly contingent on the strength of the case against the defendant.[114]

In the interest of space, I will restrict my comments to saying that Law and Neuroscience 2.0 would do well to continue these many investigations. My prediction, which I have explained recently elsewhere, is that although neuroscientific evidence is likely to be used in only a small percentage of cases, it can still have a transformative impact.[115]

(raising questions as to whether much of this evidence should be regarded as "neuroscience" evidence).

107. *See* Jessica Gurley & David Marcus, *The Effects of Neuroimaging and Brain Injury on Insanity Defenses*, 26 BEHAV. SCI. & L. 85, 85–87 (2008); David McCabe & Alan Castel, *Seeing Is Believing: The Effect of Brain Images on Judgements of Scientific Reasoning*, 107 COGNITION 343, 344 (2008); Deena Weisberg et al, *The Seductive Allure of Neuroscience Explanations*, 20 J. COGNITIVE NEUROSCIENCE 470, 470 (2008).

108. Nicholas Scurich & Adam Shniderman, *The Selective Allure of Neuroscientific Explanations*, PLOS (Sept. 10, 2014), http://dx.doi.org/10.1371/journal.pone.0107529.

109. Francis X. Shen, *Mind, Body, and the Criminal Law*, 97 MINN. L. REV. 2036, 2038–43 (2013).

110. Lisa G. Aspinwall et al., *The Double-Edged Sword: Does Biomechanism Increase or Decrease Judges' Sentencing of Psychopaths?*, 337 SCI. 846, 846–49 (2012).

111. Nicholas J. Schweitzer et al., *Neuroimages as Evidence in a Mens Rea Defense: No Impact*, 17 PSYCHOL. PUB. POL'Y & L. 357, 388–89 (2011).

112. Michael J. Saks et al., *The Impact of Neuroimages in the Sentencing Phase of Capital Trials*, 11 J. EMPIRICAL LEGAL STUD. 105, 105–07 (2014).

113. Martha Farah & Cayce J. Hook, *The Seductive Allure of "Seductive Allure,"* 8 PERSP. PSYCHOL. SCI. 88, 88–90 (2013); Robert B. Michael et al., *On the (Non)persuasive Power of a Brain Image*, 20 PSYCHONOMIC BULL. & REV. 720, 720 (2013); Adina L. Roskies et al., *Neuroimages in Court: Less Biasing than Feared*, 17 TRENDS COGNITIVE SCI. 99, 99–101 (2013).

114. Francis X. Shen, Reconsidering Brain-Based Memory Detection Evidence at William & Mary Law School Neuroscience & Criminal Responsibility Conference (2015) (on file with author).

115. Francis X. Shen, *Neuroscientific Evidence as Instant Replay*, 3 J.L. & BIOSCIENCES 343, 343 (2016).

> Like instant replay, neuroscientific evidence is more likely to be used when the stakes are high, and when judgments based on other observational data are on a borderline. And just as the use, and effect, of instant replay depends critically on the availability of proper camera angles, so too will the utility of neuroscientific evidence depend on the ability of medicine and science to provide brain data that is legally relevant.[116]

I think we can find workable solutions "to the use of neuroscientific evidence that will advance more just outcomes while not unduly delaying proceedings."[117]

We also ought to jettison the "prime time" analogy, as it is typically used: "Is neuroscience ready for prime time in court?"[118] The analogy is misleading, and to see why, just check out the latest cable and Internet offerings. The age of everyone sitting in front of their TVs to watch the same "prime time" programming is gone. And so too is it obsolete to think of neuroscience (whatever is meant by the general term "neuroscience") as only mattering if it is in a prime time slot. Just as TV programs are designed for and succeed with different audiences, so too are particular neuroscience applications likely to be useful for particular legal contexts. Additional work from legal and scientific scholars, in partnership with those in practice, can further specify which slots are best for particular neuroscientific insights and technologies.

6. Revisiting Brain-Based Memory Recognition

Much has been written on brain-based lie detection. But still ripe for further exploration is brain-based memory recognition using EEG. With great specificity and sensitivity, researchers can, on the basis of brain data, determine whether lab subjects have or have not seen particular sets of words and images.[119] But there has been correspondingly little empirical investigation of how, if at all, such approaches to memory recognition might change legal decision-making. This is in large part because the legal system's previous encounter with such evidence (in the early 1990s) was when it was introduced (problematically) in a criminal appeal in Iowa.[120] The Iowa

116. *Id.* at 343–44.

117. *Id.* at 344.

118. *Id.* at 346.

119. J. Peter Rosenfeld et al., *Review of Recent Studies and Issues Regarding the P300-Based Complex Trial Protocol for Detection of Concealed Information*, 90 INT'L J. PSYCHOPHYSIOLOGY 118, 118–19 (2013).

120. *See generally* Harrington v. State, 659 N.W.2d 509 (Iowa 2003).

Supreme Court decided on grounds other than the brain memory detection evidence, and specifically declined to rule on admissibility.[121] Memory recognition technology has fallen somewhat into disrepute in both scientific and legal circles.[122]

Yet in recent work, my lab has begun an empirical exploration of this type of evidence. I am not arguing that—given the present state of the science—courts should immediately admit brain-based memory recognition evidence. I am, however, suggesting that law ought to seriously explore the utility and admissibility of the evidence. We should engage in partnership with scientists in a systematic program of field trials to explore real-world error and success rates.

7. Addressing Mind-Body Dualism in Legal Doctrine and Practice

A number of scholars in the first wave of neurolaw scholarship recognized that the law continues to embrace substance dualism as it treats "mental" things different from "physical" things.[123] This research should continue, as it is both theoretically rich and has real-world practical consequences. To take just one of many examples, in 2005 the Red Lake Indian Reservation in

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121. *Id.* at 516 ("Because the scientific testing evidence is not necessary to a resolution of this appeal, we give it no further consideration.").

122. *See, e.g.*, Lyn M. Gaudet, *Brain Fingerprinting, Scientific Evidence, and Daubert: A Cautionary Lesson from India*, 51 JURIMETRICS 293, 306 (2011) ("As Dr. Farwell's Brain Fingerprinting remains unproven and largely ignored by the scientific community, the search in the United States for an unbeatable lie detector has taken a different path."); Henry T. Greely & Judy Illes, *Neuroscience-Based Lie Detection: The Urgent Need for Regulation*, 33 AM. J.L. & MED. 377, 388 (2007) ("Farwell's claims are widely discounted in the relevant scientific community and his credibility is not helped by his inflated claims for the judicial acceptance of his technique.").

123. *See, e.g.*, Avlana K. Eisenberg, *Criminal Infliction of Emotional Distress*, 113 MICH. L. REV. 607, 614 (2015); Dov Fox & Alex Stein, *Dualism and Doctrine*, 90 IND. L.J. 975, 977 (2015); Erica Goldberg, *Emotional Duties*, 47 CONN. L. REV. 809, 811 (2015); Betsy J. Grey, *The Future of Emotional Harm*, 83 FORDHAM L. REV. 2605, 2607 (2015); Betsy J. Grey, *Neuroscience, Emotional Harm, and Emotional Distress Tort Claims*, 7 AM. J. BIOETHICS 65, 66 (2007); Betsy J. Grey, *Neuroscience and Emotional Harm in Tort Law: Rethinking the American Approach to Free-Standing Emotional Distress Claims*, *in* LAW AND NEUROSCIENCE: CURRENT LEGAL ISSUES 203, 211 (Michael Freeman ed., 2011); Govind Persad, *Law, Science, and the Injured Mind*, 67 ALA. L. REV. 1179, 1181 (2016); Shen, *supra* note 109, at 2048; Francis X. Shen, *Sentencing Enhancement and the Crime Victim's Brain*, 46 LOY. U. CHI. L.J. 405, 407 (2014); Stacey A. Tovino, *All Illnesses Are (Not) Created Equal: Reforming Federal Mental Health Insurance Law*, 49 HARV. J. ON LEGIS. 1, 2 (2012); Stacey A. Tovino, *Neuroscience and Health Law: An Integrative Approach?*, 42 AKRON L. REV. 469, 489 (2009); Jennifer A. Chandler, *The Impact of Biological Psychiatry on the Law: Evidence, Blame and Social Solidarity*, 54 ALBERTA L. REV. (forthcoming 2017), http://ssrn.com/abstract=2815544 (manuscript at 14).

northern Minnesota became the site of a tragic school shooting.[124] Ten people died over the course of the day, and many teachers and students at Red Lake High School were injured.[125] About a dozen of the teachers who witnessed the violence, but were not "physically" injured, subsequently experienced Post-Traumatic Stress Disorder (PTSD) and sought workers compensation to cover lost wages when they were unable to work due to the mental injuries.[126] But they met a legal road block: Minnesota law did not (at that time) allow for workers compensation for purely "mental" injuries.[127]

A debate in the legislature ensued about whether the law should be changed. Opponents, who wished to keep the law as it was, argued that "[w]e have to look at what's good for the workers' compensation system for our membership . . . . We can't afford to become less competitive than we are currently, and we just don't think this is a change that will make Minnesota a better place to do business."[128] On the other side, an advocate for changing the law observed, "We will sooner than later have a definitive answer to why people develop PTSD from that kind of trauma . . . Just like you do a blood test for syphilis or an X-ray for osteoporosis, we'll have that at some point. It's just not quite there yet, but sooner or later, the law will have to change to incorporate that."[129] The law was eventually changed, and in some cases litigants successfully argued that in fact their PTSD was a physical injury.[130] These types of substantive legislative and case outcomes are indications that investigation into mind-body doctrine is of great consequence.

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124. John Enger, *Feeling Scars at Red Lake, 10 Years Later*, MPRNEWS (Mar. 18, 2015), http://www.mprnews.org/story/2015/03/18/red-lake-shooting-10-years.

125. *Id.*

126. *Id.*

127. *Red Lake Teachers Ask for Compensation*, CBS MINN. (Dec. 10, 2010, 12:17 PM), http://minnesota.cbslocal.com/2010/12/10/red-lake-teachers-compensation/.

128. *Id.*

129. *Id.*

130. Case results were mixed, but at least some were victorious in court. Molly Miron, *Red Lake High School Shooting: Teacher Wins Landmark Case*, BEMIDJI PIONEER (Mar. 3, 2009, 12:18 AM), http://www.bemidjipioneer.com/content/red-lake-high-school-shooting-teacher-wins-landmark-case ("This case is compensable because . . . the mental stimulus, which was the extreme mental stress that the employee experienced at work on March 21, 2005, produced a physical injury to the employee's brain that has left her with severe and unrelenting PTSD, depression and anxiety . . . . The mental stimulus also produced physical injury to the neck and shoulders, which would make the case compensable even if there is no physical injury to the brain.").

8. Revisiting Brain Death and Disorders of Consciousness

In the history of law and neuroscience, debates over brain death and the law play a prominent role.[131] The "Harvard Report" of 1968 put into motion what would eventually become the Universal Declaration of Death Act.[132] Today, all fifty states have recognized neurological criteria for determining death.[133] The 1980s saw a flurry of literature in both medicine and law debating the topic,[134] and the Terri Schaivo case in the 2000s made national headlines.[135]

Delineating the line between life and death has been a challenging medical and legal question for centuries, and it will continue to be a ripe area for neurolaw exploration.[136] This is especially so because of new technologies that—for the first time—might allow some patients with certain disorders of consciousness (such as locked-in syndrome) to communicate via brain imaging.[137] Walter Sinnott-Armstrong's 2016 edited volume, *Finding Consciousness*, explores many of the ethical, legal, and scientific issues raised by these new technologies.[138] I agree with Sinnott-Armstrong and co-author Meghan Brayton when they write that disorders of consciousness "raise profound issues for courts and policymakers and will stimulate much debate both inside and outside of academia for decades to come."[139] I hope that these issues remain central to the neurolaw agenda.

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131. For an excellent review, see ELIZABETH PRICE FOLEY, THE LAW OF LIFE AND DEATH (2011).

132. Comm. to Examine the Definition of Brain Death, Harv. Med. Sch., *A Definition of Irreversible Coma*, 205 [J]AMA 337, 337–40 (1968).

133. JONES ET AL., *supra* note 8, at 269–302.

134. *See, e.g.*, PRESIDENT'S COMM'N FOR THE STUDY OF ETHICAL PROBLEMS IN MED. AND BIOMEDICAL & BEHAV. RES., DEFINING DEATH: MEDICAL, LEGAL AND ETHICAL ISSUES IN THE DETERMINATION OF DEATH 45–84 (1981); Faroque A. Khan et al., *Brain Death and the Law*, *in* LEGAL ASPECTS OF MEDICINE 191, 191–99 (Frank P. Stuart et al. eds., 1989).

135. JONES ET AL., *supra* note 8, at 269–70.

136. *Id.*; *see also* Joseph J. Fins, *Brain Injury: The Vegetative and Minimally Conscious States*, *in* FROM BIRTH TO DEATH AND BENCH TO CLINIC: THE HASTINGS CENTER BIOETHICS BRIEFING BOOK FOR JOURNALISTS, POLICYMAKERS, AND CAMPAIGNS 15–20 (Mary Crowley ed., 2008).

137. Adrian M. Owen et al., *A New Era of Coma and Consciousness Science*, 177 PROG. BRAIN RES. 399 (2009)

138. FINDING CONSCIOUSNESS: THE NEUROSCIENCE, ETHICS, AND LAW OF SEVERE BRAIN DAMAGE (Walter Sinnott-Armstrong ed., 2016).

139. Meghan Brayton & Walter Sinnott-Armstrong, *Finding Consciousness*, *in* FINDING CONSCIOUSNESS: THE NEUROSCIENCE, ETHICS, AND LAW OF SEVERE BRAIN DAMAGE 1, 11 (Walter Sinnott-Armstrong ed., 2016).

9. Cognitive Enhancement Through Direct Brain Intervention

In the past fifteen years, much has been written by scholars on human cognitive enhancement.[140] The possibilities are tantalizing. As neuroscientist David Eagleman says at the conclusion of his PBS series *The Brain*, "Our brains don't have to remain as we've inherited them. . . . Our species is just at the beginning of something. . . . Who we become is up to us."[141] Who we become is up to us—but within the confines of legally permissible behavior.

Given the growing marketplace of new (if not necessarily effective) enhancement technologies, drawing legal boundaries will become increasingly important. The topics are newsworthy as well as legally salient. In the 2016 Rio Olympics, several athletes used the Halo system in an effort to gain a competitive edge.[142] Purportedly, Halo provides targeted stimulation via transcranial Direct Current Stimulation (tDCS), which will (in the CEO's words) "literally make your brain stronger and more skilled."[143] But does the system work as proclaimed? We have no idea because there has been zero published research. This doesn't seem to bother Halo CEO Danny Chau, who responds that "Academics are really interested in us publishing something. As a for-profit company, that's not our mandate . . . I have a fiduciary responsibility to build a business here. Patents come before publications."[144] Chau's position invites both ethical and legal commentary.

Perhaps his company will meet the same fate as the "brain training" firm Lumosity did in 2016. Lumosity marketed its games widely as based on the science of neuroplasticity and proven to be effective in boosting certain cognitive skills.[145] In 2016, the Federal Trade Commission announced a

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140. *See*, *e.g.*, HUMAN ENHANCEMENT (Julian Savulescu & Nick Bostrom eds., 2009); Henry T. Greely, *Regulating Human Biological Enhancements: Questionable Justifications and International Complications*, 4 SANTA CLARA J. INT'L L. 87, 94–96 (2006); Henry T. Greely, *Remarks on Human Biological Enhancement*, 56 U. KAN. L. REV. 1139, 1146–47 (2008); Henry Greely et al., *Towards Responsible Use of Cognitive-Enhancing Drugs by the Healthy*, 456 NATURE 702, 702–05 (2008); Jasper L. Tran & Derek Tri Tran, *(De)regulating Neuroenhancement*, 37 U. LA VERNE L. REV. 179, 203 (2015).

141. *The Brain with David Eagleman: Who Will We Be?* (PBS television broadcast Nov. 18, 2015).

142. Kate Knibbs, *The Brain-Zapping Olympians*, RINGER (Aug. 4, 2016), https://theringer.com/halo-sport-olympics-neuroscience-353f7f0d9ffe#.gtz2oj4aa.

143. Natasha Lomas, *Halo Is Building a Wearable to Make Athletes Better, Stronger, Faster*, TECHCRUNCH (May 9, 2016), https://techcrunch.com/2016/05/09/halo-is-building-a-wearable-to-make-athletes-better-stronger-faster/.

144. Knibbs, *supra* note 142.

145. Paula Span, *F.T.C.'s Lumosity Penalty Doesn't End Brain Training Debate*, N.Y. TIMES (Jan. 15, 2016), http://www.nytimes.com/2016/01/19/health/ftcs-lumosity-penalty-doesnt-end-brain-training-debate.html.

settlement with Lumosity, with regard to its "brain training" program.[146] The agreement requires Lumosity "to have competent and reliable scientific evidence before making future claims about any benefits for real-world performance, age-related decline, or other health conditions."[147] And there is a fifty million dollar judgment (two million of which was payable in 2016).[148] This was a welcome development, and it was followed in May 2016 with a judgment against LearningRx for similar types of unsupported claims.[149] In a settlement, LearningRx is prohibited from making a number of claims about improved cognitive performance until they "possess and rely upon competent and reliable scientific evidence to substantiate that the representation is true."[150]

The recent examples of FTC regulation of Lumosity and LearningRx, combined with the FDA's recent interest in enhancement via brain stimulation, suggests that this will continue to be an active area for legal actors and scholars.

10. Governance of Induced Pluripotent Stem Cell Human Chimeras Research

For over a decade, bioethics scholars and law professors have explored the ethical issues associated with the transplantation of human stem cells into prenatal non-humans.[151] The ethics literature has debated many issues, including human dignity and animal cruelty. But scientific research is moving

146. Press Release, FTC, Lumosity to Pay $2 Million to Settle FTC Deceptive Advertising Charges for Its "Brain Training" Program (Jan. 5, 2016), https://www.ftc.gov/news-events/press-releases/2016/01/lumosity-pay-2-million-settle-ftc-deceptive-advertising-charges.

147. *Id.*

148. *Id.*

149. Press Release, FTC, Marketers of One-on-One 'Brain Training' Programs Settle FTC Charges that Claims About Ability to Treat Severe Cognitive Impairments Are Unsupported (May 18, 2016), https://www.ftc.gov/enforcement/cases-proceedings/142-3206/learningrx-franchise-corp.

150. FTC v. LearningRx Franchise Corp., No. 1:16-cv-01159-RM, at 6 (D. Colo. May 24, 2016), https://www.ftc.gov/system/files/documents/cases/160524learningrxorder.pdf.

151. Francoise Baylis & Jason Scott Robert, *Part-Human Chimeras: Worrying the Facts, Probing the Ethics*, 7 AM. J. BIOETHICS 41, 41–45 (2007); Henry T. Greely, *Human/Nonhuman Chimeras: Assessing the Issues*, *in* THE OXFORD HANDBOOK OF ANIMAL ETHICS 671 (Tom L. Beauchamp & R. G. Frey eds., 2011); Phillip Karpowicz et al., *It Is Ethical to Transplant Human Stem Cells into Nonhuman Embryos*, 10 NATURE MED. 331, 331–35 (2004); Christopher Thomas Scott, *Chimeras in the Crosshairs*, 24 NATURE BIOTECHNOLOGY 487, 487–90 (2006).

fast in this area.[152] Notably, researchers are now using induced pluripotent stem (iPS) cells, which can differentiate into cells such as neurons, hematopoietic cells, and liver cells, to improve regenerative medicine.[153] The pertinent question is no longer "if" human-nonhuman chimera research should proceed (since it is already proceeding), but rather how such research can be most effectively and ethically governed.

The NIH has debated funding such research, and may lift a temporary moratorium that had been imposed.[154] At present the governance of iPS human-nonhuman chimera research falls between several regulatory regimes. Given this regulatory uncertainty, and the speed at which these technologies are developing, there are many legal questions about governance as well as about intellectual property and informed consent. A thorough legal analysis would be of great practical use, as well as theoretically rich as it would touch upon what constitutes "humanizing" a non-human animal.

11. Privacy and Brain Hacking

Legal scholars Nita Farahany[155] and Marc Blitz,[156] amongst others,[157] have begun to explore mental privacy. While at present I believe the "mind reading" capabilities of brain technologies do not raise constitutional concerns, privacy discussions will become more salient as the technology progresses. Continued discussion with privacy scholars is surely warranted.

Brain-Computer Interface invites the possibility that—just as computers can be hacked to get into your checking account—computers could be hacked

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152. Julio Licinio & M. L. Wong, *Serotonergic Neurons Derived from Induced Pluripotent Stem Cells (iPSCs): A New Pathway for Research on the Biology and Pharmacology of Major Depression*, 21 MOLECULAR PSYCHIATRY 1 (2016).

153. Ayaka Yanagida et al., *Generation and In Vitro Expansion of Hepatic Progenitor Cells from Human iPS Cells*, 1357 METHODS MOLECULAR BIOLOGY 295, 295 (2015).

154. Jocelyn Kaiser, *NIH Moves to Lift Moratorium on Animal-Human Chimera Research*, SCI. (Aug. 4, 2016), http://www.sciencemag.org/news/2016/08/nih-moves-lift-moratorium-animal-human-chimera-research.

155. Nita A. Farahany, *Incriminating Thoughts*, 64 STAN. L. REV. 351, 406 (2012); Nita A. Farahany, *Searching Secrets*, 160 U. PA. L. REV. 1239, 1239 (2012).

156. Marc Jonathan Blitz, *Freedom of Thought for the Extended Mind: Cognitive Enhancement and the Constitution*, 2010 WIS. L. REV. 1049, 1049.

157. *See also* SARAH D. RICHMOND ET AL., I KNOW WHAT YOU'RE THINKING: BRAIN IMAGING AND MENTAL PRIVACY (2012); Christian Halliburton, *Letting* Katz *out of the Bag: Cognitive Freedom and Fourth Amendment Fidelity*, 59 HASTINGS L.J. 309, 309 (2007); Francis X. Shen, *Neuroscience, Mental Privacy, and the Law*, 36 HARV. J.L. & PUB. POL'Y 653, 653 (2013).

to access the technology modulating your brain activity.[158] This is an excellent place for legal thinkers to contribute, as often the BCI device manufacturers themselves "are developing devices and applications without taking much the security and privacy issues into account."[159] To date, scholarship in this area has not been extensive.[160]

In the realm of security, consider the following scenario. For over twenty-five years individuals have had brain stimulation devices implanted in their brains to treat Parkinson's.[161] Researchers are now exploring the use of "smart stimulators" in an effort to further improve health.[162] If hackers were able to remotely override the brain-computer interface system that governed the stimulation settings, they could conceivably cause significant damage to the patient with the implanted device. Except for a sadist, inflicting such pain (or even death) would be unproductive. But what might be very lucrative would be to quietly (or not so quietly) approach the device manufactuer(s) with a simple deal: give us a ton of money, or we're going to kill your patients and take down your company in the process. The hacker might agree, in exchange, to hand over their hacking code—allowing the company to quickly reprogram their equipment, and avoid a devastating lawsuit and loss of life. For a terrorist sitting thousands of miles away, this might seem an appealing route to take. Security and legal expertise should be at the forefront of thinking through, and eliminating (or at least severely limiting) the possibility, of such scenarios.

12. Artificial Intelligence

The last chapter in the *Law and Neuroscience* coursebook that I co-authored in 2014 with Owen Jones and Jeffrey Schall concerns artificial

158. Marcello Ienca & Pim Haselager, *Hacking the Brain: Brain-Computer Interfacing Technology and the Ethics of Neurosecurity*, 18 ETHICS & INFO. TECH. 117, 117 (2016).

159. QianQian Li et al., *Brain-Computer Interface Applications: Security and Privacy Challenges*, RESEARCHGATE, https://www.researchgate.net/publication/280948092_Brain-Computer_Interface_Applications_Security_and_Privacy_Challenges (last visited January 16, 2017).

160. Scott Kiel-Chisholm & John Devereux, *The Ghost in the Machine: Legal Challenges of Neural Interface Devices*, 23 TORT L. REV. 32 (2015); Stephen S. Wu & Marc Goodman, *Neural Devices Will Change Humankind: What Legal Issues Will Follow?*, 8 A.B.A. SCITECH LAW. 12 (2012).

161. Marwan Hariz, *Twenty-Five Years of Deep Brain Stimulation: Celebrations and Apprehensions*, 27 MOVEMENT DISORDERS 930 (2012).

162. Julien Modolo et al., *Using "Smart Stimulators" to Treat Parkinson's Disease: Re-Engineering Neurostimulation Devices*, 6 FRONTIERS COMPUTATIONAL NEUROSCIENCE 69 (2012).

intelligence.[163] When I teach my law and neuroscience course, and we reach this final chapter, I tell students it may well be the most important chapter in the book. This is because our future is one where machines are increasingly "outperforming and outthinking humans."[164]

Dr. Fei-Fei Li, who runs the Stanford Artificial Intelligence Laboratory, sums it up nicely: "We live in a mind-blowingly different world than our grandparents."[165] Much of what will be mind-blowing for the generations ahead concerns the development of artificial intelligence.

There is so much to work on at the intersection of artificial intelligence and the law it deserves its own forum. Thankfully, the International Association for Artificial Intelligence and Law, as well as the *Artificial Intelligence and Law* journal, provide such a forum.[166] Neurolaw—perhaps again because it has been so caught up in questions of criminal responsibility—has not engaged with the AI community as much as it could. A challenge for Law and Neuroscience 2.0 is to better integrate with these communities of AI scholars and practitioners.

13. Virtual Reality and the Law

Virtual Reality (VR) is now being explored for an incredible range of uses, including treating mental health problems,[167] helping football players improve their technique,[168] disaster training,[169] and of course video games.[170] Regulators, legislators, practicing attorneys, and scholars have already begun to weigh in on issues such as intellectual property,[171] privacy,[172] and constitutional law.[173] As law professor and neurolaw scholar Marc Blitz has

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163. JONES ET AL., *supra* note 8, at 685.

164. Benjamin Alarie et al., Law in the Future 1, 1 (May 31, 2016) (unpublished manuscript), http://ssrn.com/abstract=2787473.

165. Declan Butler, *Tomorrow's World*, 530 NATURE 398, 399 (2016).

166. INT'L ASS'N ARTIFICIAL INTELLIGENCE & L., http://www.iaail.org (last visited Jan. 5, 2017).

167. Lucia R. Valmaggia et al., *Virtual Reality in the Psychological Treatment for Mental Health Problems: A Systematic Review of Recent Evidence*, 236 PSYCHIATRY RES. 189 (2016).

168. STRIVR, http://www.strivrlabs.com/ (last visited Jan. 5, 2017).

169. Sharon L. Farra et al., *Virtual Reality Disaster Training: Translation to Practice*, 15 NURSE EDUC. PRAC. 53 (2015).

170. Leena M. Sheet & A. Benjamin Katz, *Protecting Rights in Videogames: Next Generation Licensing*, 6 VA. SPORTS & ENT. L.J. 124, 124–25 (2006).

171. *Id.* at 127.

172. Paul Merrion, *Virtual Reality Hardware Raises Real Privacy Questions, Franken Says*, CONG. Q., Apr. 8, 2016, 2016 WL 2842698.

173. Marc Jonathan Blitz, *The Freedom of 3D Thought: The First Amendment in Virtual Reality*, 30 CARDOZO L. REV. 1141 (2008).

suggested, VR may lead us to a real-world equivalent of the famous "Experience Machine" imagined by Robert Nozick (and brought to the silver screen in the movie *Surrogates*).[174] Blitz and others have opened up the issues, and it's up to Law and Neuroscience 2.0 to follow up in this space.

For instance, at present we impose neither tort nor criminal liability for harmful thoughts. But if VR makes those thoughts more vivid—do we feel (and importantly, do legislators feel) the same way? Consider a hypothetical man named Mr. A, who is fifty years old. If Mr. A uses his VR technology to imagine having consensual sex with a fifteen-year old girl, do we impose any sort of liability? Do we prevent VR manufacturers from creating games that allow for such scenes? If we did, and then Mr. A reprogrammed it himself, would we treat him differently? All of this of course begs questions about evidence as well. How would we know what experiences Mr. A had while using his VR machine? Would they all be recorded?

One also wonders how virtual reality tools might become litigation aids. For instance, accident scene reconstructions are regularly admitted into evidence. How would we handle a virtual reconstruction? Could jurors all strap on VR devices and take a stroll around the crime or accident scene? Some of these questions are a bit fanciful. But some are not, given the pace of technological development.

14. Non-Human Animal Brains and Non-Human Animal Rights

It has not gained much attention in the mainstream of neurolaw research, but it should: we are living through a potentially revolutionary moment in the recognition of legal rights for animals.[175] One of the core legal arguments concerns the animals' cognitive (i.e., brain) function.[176] The Great Ape Project has been working since 1993 to secure legal rights for non-human great apes.[177] Recently, the Nonhuman Rights Project made headlines for filing a habeas corpus petition on behalf of two chimpanzees, asking that they

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174. *Id.* at 1152.

175. Adam Kolber, Note, *Standing Upright: The Moral and Legal Standing of Humans and Other Apes*, 54 STAN. L. REV. 163 (2001) (identifying many of the core legal questions in an exploration of the Great Ape Project's efforts to achieve legal rights for great apes).

176. Lesley J. Rogers & Gisela Kaplan, *All Animals Are Not Equal: The Interface Between Scientific Knowledge and Legislation for Animal Rights*, *in* ANIMAL RIGHTS: CURRENT DEBATES AND NEW DIRECTIONS 175 (Cass. R. Sustein & Martha C. Nussbaum eds., 2005) (discussing intelligence). For alternative approaches, see David S. Favre, *Judicial Recognition of the Interests of Animals—A New Tort*, 2005 MICH. ST. L. REV. 333.

177. *History*, GREAT APE PROJECT, http://www.projetogap.org.br/en/history/ (last visited Jan. 5, 2017).

be released from confinement.[178] And in 2012, a group of scientists (including many neuroscientists) signed the *Cambridge Declaration on Consciousness*, which declared that "the weight of evidence indicates that humans are not unique in possessing the neurological substrates that generate consciousness."[179]

The intersection of non-human animal brains and animal rights seems another area ripe for informed, interdisciplinary collaboration and engagement. For instance, if we think that the brains of mice, rats, and many other animals we regularly study (and kill) are sufficiently like the human brain to provide important translational insights, at what point are they *so much* like the human brain as to receive more legal protections? Animal rights scholars and activists have debated such questions for decades, but the issues will remain ripe as we continue to learn more about the relationship between the brains of human and non-humans.[180]

15. Global Neurolaw

The last of my fifteen possibilities concerns prospects of global neurolaw. To date, the bulk of scholarship (like the bulk of scholarship in many other fields) is heavily U.S. and European centric. This reflects neuroscience research more generally, which remains challenging to do in the developing world.[181]

Law has become increasingly international over the past five decades, as have fields such as political science, economics, sociology, and public health. Can neurolaw do the same? It would take some paradigm-shifting work, but

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178. *See* Nonhuman Rights Project, Inc. v. Stanley, 16 N.Y.S.3d 898, 900 (2015); *NhRP Re-Files Habeas Corpus Case on Behalf of Tommy in New York*, NONHUMAN RTS. PROJECT (Dec. 4, 2015), http://www.nonhumanrightsproject.org/2015/12/04/nhrp-re-files-habeas-corpus-case-on-behalf-of-tommy-in-new-york/.

179. Philip Low, *The Cambridge Declaration on Consciousness*, FRANCIS CRICK MEM'L CONFERENCE ON CONSCIOUSNESS IN HUMAN & NON-HUMAN ANIMALS 1, 2 (July 7, 2012), http://fcmconference.org/img/CambridgeDeclarationOnConsciousness.pdf.

180. Ben Guarino, *How Many Lab Mice Did American Researchers Kill in 2015?*, INVERSE (Dec. 17, 2015), https://www.inverse.com/article/9316-how-many-lab-mice-did-american-researchers-kill-in-2015 ("Extrapolating the data from the PETA study, however, gives us about 86 million annual mice and rats, a guess that Herzog believes is closest.").

181. Paul Smaglik, *Neuroscience in the Developing World*, 451 NATURE 1136, 1136 (2008); Alla Katsnelson, *Developing Neuroscience*, SCIENTIST (Nov. 14, 2003), http://www.the-scientist.com/?articles.view/articleNo/22592/title/Developing-neuroscience/; *Brain Science: Mapping the Landscape of Brain and Neuroscience Research*, ELSEVIER 1, 3 (2014) [hereinafter *Brain Science*], https://www.elsevier.com/__data/assets/pdf_file/0004/53455/ElsevierBrainScienceReport2014-web.pdf (noting that neuroscience research is predominantly conducted in the United States, United Kingdom, China, Germany, and Japan).

an energetic, creative, culturally sensitive, and interdisciplinary team could make real headway in this area.

To offer just one idea, a 2012 report by Human Rights Watch found that in Ghana, an estimated 650,000 people are thought to have serious mental disabilities.[182] There are severely inadequate services, however, and many believe that the mental disorders are caused by evil spirits.[183] Moreover, there are hundreds of "prayer camps," in which "prophets" (self-proclaimed) "treat" patients without training, sometimes including chaining them until declared (by the prophet) healed.[184]

In such contexts, could we develop a culturally-appropriate education program about the brain-basis of mental disorder? Could we use mobile neurotechnology to document brain abuse? In the same way that lawyers with economics and financial backgrounds help governments develop and stabilize financial markets, could international neurolawyers help national and local authorities more effectively help their citizens seeking brain health? I hope a new generation of neurolaw practitioners begin to explore such questions.

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I will stop at fifteen examples in light of the symposium length limit (which I have already overstepped), but I will close this Part with two quick notes. The first is that many (probably most) of the issues above will be resolved in legislative and policymaking arenas, not courtrooms. Thus, as I have argued at length elsewhere, we need further investigation on the use of neuroscience by legislators and policymakers.[185]

Second, note that these fifteen are only a handful of the possibilities for Law and Neuroscience 2.0. We skipped all of criminal justice, brain injury, and pain. And with more space, we might consider further intersections with mental health law, forensic psychiatry, pharmacology, neuroengineering and brain-machine interface, biases and decision-making, transhumanism, informed consent, property in neuronal cell lines, criminal treatment, and much more. It is this breadth of possibility that fuels my excitement for this arena.

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182. Medi Ssengooba et al., *"Like a Death Sentence:" Abuses Against Persons with Mental Disabilities in Ghana*, HUM. RTS. WATCH (Oct. 2, 2012), https://www.hrw.org/report/2012/10/02/death-sentence/abuses-against-persons-mental-disabilities-ghana.

183. *Id.*

184. *Id.*

185. Francis X. Shen, *Neurolegislation: How U.S. Legislators Are Using Brain Science*, 29 HARV. J.L. & TECH. 495 (2016).

III. A BLUEPRINT FOR LAW AND NEUROSCIENCE 2.0

I've argued thus far that we have many neurolaw possibilities to pursue, and a strong foundation from which to launch our pursuits. In this Part, I discuss what I think we need to do to be successful in those pursuits. I focus on the following essential ingredients: (A) scientific breakthroughs, (B) funding and financing, and (C) training and careers in neurolaw.

A. Scientific Breakthroughs

The most obvious, but also the most important, fact about neuroscience is this: there is an unprecedented amount of neuroscience research currently underway. A recent analysis suggests that in the five-year span from 2009 to 2013 there were nearly *two million* articles published in brain and neuroscience research, representing sixteen percent of the world's scholarly publication output.[186] That means you could give a unique publication to every single resident of the City of Philadelphia and still have hundreds of thousands left over.[187] There is a bewildering amount of neuroscience research underway.

A few trends in the research should be mentioned to illustrate where the discipline is headed. The new mantra in neuroscience is circuits, not centers.[188] The focus now is less on discovering how discrete areas of the brain work in isolation, and much more on how many areas of the brain work in concert with one another.[189] This is the centerpiece of the Human Connectome Project, a multi-site investigation to see how different brain regions are wired together. In 2016 a landmark study from the Project[190] presented "a spectacular new map of the brain, detailing nearly 100

186. *Brain Science*, *supra* note 181.

187. *Quickfacts: Philadelphia City, Pennsylvania*, U.S. CENSUS BUREAU, http://www.census.gov/quickfacts/table/PST045215/4260000 (last visited Jan. 5, 2017).

188. Cornelia I. Bargmann, *How the New Neuroscience Will Advance Medicine*, 314 JAMA 221, 221 (2015) ("Modern neuroscience increasingly emphasizes a view of the brain as a set of information processing circuits or systems, not isolated neurons and regions.").

189. Ed Bullmore & Olaf Sporns, *The Economy of Brain Network Organization*, 13 NATURE REVS. NEUROSCIENCE 336, 340 (2012) ("The increasing availability of empirical data on brain networks . . . has triggered concerted efforts to create comprehensive connectivity maps (connectomes) for various organisms, including humans.").

190. Matthew F. Glasser et al., *A Multi-Modal Parcellation of Human Cerebral Cortex*, 536 NATURE 171 (2016).

previously unknown regions—an unprecedented glimpse into the machinery of the human mind."[191]

New technologies are fueling new discoveries, and in particular scientists are looking for ways to bypass the skull. These include, for instance, the development of soft polymer mesh implants,[192] and the "window to the brain" platform which focuses on using laser-based treatments.[193] A Harvard research team led by chemist Charles Lieber is now using, in mice, a "mesh of conductive polymer threads with either nanoscale electrodes or transistors attached at their intersections."[194] Because the mesh has much free space, cells can arrange themselves around the mesh, allowing for both recording and activation.[195] While it will take time for this technology to advance to the point where it can be used reliably in humans, it is indicative of the novel, creative ways in which scientists are advancing the field.

Another promising development, led by Stanford neuroscientist Karl Deisseroth, is optogenetics.[196] Optogenetics is a method that allows for control of neurons, with a level of precision not previously available, via genetic manipulation of cells and light to then activate (or deactivate) those cells. Private investment in optogenetics is commencing,[197] and in the world of neuroscience Deisseroth is a rock star.[198] For neurolaw, the implications are not entirely clear. On one hand, this is not (as Deisseroth makes clear) a

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191. Carl Zimmer, *Updated Brain Map Identifies Nearly 100 New Regions*, N.Y. TIMES (July 20, 2016), http://www.nytimes.com/2016/07/21/science/human-connectome-brain-map.html?_r=0.

192. Jia Liu et al., *Syringe-Injectable Electronics*, 10 NATURE NANOTECHNOLOGY 629 (2015).

193. Yasaman Damestani et al., *Evaluation of Laser Bacterial Anti-Fouling of Transparent Nanocrystalline Yttria-Stabilized-Zirconia Cranial Implant*, LASERS SURGERY & MED. 1, 1 (2016) (discussing how the "fundamental aim of the window to the brain (WttB) implant/platform is to improve patient care by providing a technique for delivery and/or collection of light into/from the brain, on demand, over large areas, and on a chronically recurring basis without the need for repeated craniotomies").

194. Elizabeth Gibney, *Injectable Brain Implant Spies on Individual Neurons*, NATURE (June 8, 2015), http://www.nature.com/news/injectable-brain-implant-spies-on-individual-neurons-1.17713.

195. *Id.*

196. Gary Aston-Jones & Karl Deisseroth, *Recent Advances in Optogenetics and Pharmacogenetics*, 1511 BRAIN RES. 1 (2013); Lief Fenno et al., *The Development and Application of Optogenetics*, 34 ANN. REV. NEUROSCIENCE 389 (2011).

197. Stephani Sutherland, *Revolutionary Neuroscience Technique Slated for Human Clinical Trials*, SCI. AM. (Jan. 5, 2016), http://www.scientificamerican.com/article/revolutionary-neuroscience-technique-slated-for-human-clinical-trials/.

198. John Colapinto, *Lighting the Brain: Karl Deisseroth and the Optogenetics Breakthrough*, NEW YORKER (May 18, 2015), http://www.newyorker.com/magazine/2015/05/18/lighting-the-brain.

breakthrough that will unpack the mind.[199] On the other hand, however, the technique could eventually lead to new treatments for pain and psychiatric disorders.

In addition, investment in neuroscience by private industry may be on the comeback. Research by big pharma has been on the decline in the past five years.[200] But neuroscience may be hot again. In 2015 there were new, venture capital investments in brain companies aimed at addressing neurological diseases.[201] In 2016, a series of launches and acquisitions occurred in the neuroscience space.[202] A number of universities and medical centers across the country are also investing in neuroscience.[203] The University of California, San Francisco (UCSF) received its largest ever donation, $185

199. *Id.* (quoting Deisseroth as saying "It's just too early to ask" questions about the bigger mystery of the mind).

200. Kate Kelland, *Analysis: Neuroscience Under Threat as Big Pharma Backs Off*, REUTERS (Feb. 11, 2011), http://www.reuters.com/article/us-neuroscience-pharma-idUSTRE71A2E120110211; Sten Stovall, *R&D Cuts Curb Brain-Drug Pipeline*, WALL STREET J. (Mar. 27, 2011), http://www.wsj.com/articles/SB10001424052748704474804576222463927753954. Part of the reason is failed drug trials for Alzheimer's. Shane O'Mara, *When Will Neuroscience Blow Our Minds?*, TIMES HIGHER EDUC. (Aug. 4, 2016), https://www.timeshighereducation.com/features/when-will-neuroscience-blow-our-minds ("The hundred or so failed drug trials for Alzheimer's disease have come at a cost reckoned in the billions . . . and many have now written off research in brain diseases as too complex and too costly to sustain.").

201. Alex Lash, *Amid Neuroscience Renaissance, BlackThorn Quietly Builds a Business*, XCONOMY (Dec. 23, 2015), http://www.xconomy.com/san-francisco/2015/12/23/amid-neuroscience-renaissance-blackthorn-quietly-builds-a-business/?single_page=true ("The past year has seen several new biotech companies announce ambitious goals of tackling neurological disease, a vast, complex, and frustrating region of biomedicine.").

202. Ben Adams, *GlaxoSmithKline, Sanford Burnham Launch Neuroscience Hub*, FIERCE BIOTECH (Apr. 20, 2016), http://www.fiercebiotech.com/research/glaxosmithkline-sanford-burnham-launch-neuroscience-hub (announcing that "Sanford Burnham Prebys Medical Discovery Institute and London's GlaxoSmithKline ($GSK) have teamed up to launch a new 'SBP-GSK Center for Translational Neuroscience'" in La Jolla, California); Amirah Al Idrus, *Myriad Enters Neuroscience with $225M Assurex Health Buy*, FIERCE BIOTECH (Aug. 4, 2016), http://www.fiercebiotech.com/medical-devices/myriad-enters-neuroscience-225m-assurex-health-buy (reporting that Myriad Genetics acquired Assurex Health for $225 million in order to serve as a "launchpad for the company's in-development neuroscience offerings, including myPath Bipolar, a differential diagnosis tool for bipolar disorder and major depressive disorder"); John Carroll, *Biotech Entrepreneurs Grab $49M to Bankroll a Neuroscience Startup*, FIERCE BIOTECH (May 25, 2016), http://www.fiercebiotech.com/biotech-entrepreneurs-raise-49m-to-bankroll-a-neuroscience-startup (Jazz Pharmaceuticals, a self-described "neuroscience-focused company," launched Arrivo Bioventures with $49 million.).

203. For instance, in 2016, Purdue University's Institute for Integrative Neuroscience has received a multimillion-dollar gift. *Krenicki Family Funds Purdue Neuroscience Directorship*, PHOTONICS MEDIA (May 18, 2016), http://www.photonics.com/Article.aspx?AID=60696.

million, to fund a new neuroscience research facility.[204] Verily Life Sciences, the sister company of Google, also is developing bioelectric implants with a $700 million commitment announced in 2016.[205] And as one headline read, "Hospitals Bet on Neuroscience."[206]

With significant investment from the private sector, and two million research publications every five years, I find it hard to believe that we will not be able to make big leaps in our understanding of the brain's circuitry, and thus of its many legally-relevant cognitive functions.

B. Funding and Financing: We need a Viable Business Model

A healthy stream of neuroscience funding now exists.[207] But what about funding for neuro*law*?

With the MacArthur Foundation's investment (which totaled about $15 million over 10 years) coming to a close, the field will be searching for new ways to stay viable. University-funded centers will provide some resources.[208] We also owe a debt to Hank Greely, who serves as the neuroethics representative on the Multi-Council Working Group on the NIH BRAIN Initiative (MCWG). Thanks to Greely's leadership, a MCWG Neuroethics Work Group now exists and funding for neuroethics issues related to NIH BRAIN Initiative projects has been made possible.[209] To its

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204. Lori Roniger, *New, Large Neuroscience Institute Will Study a Variety of Brain Disorders*, HEALTHLINE (May 24, 2016), http://www.healthline.com/health-news/new-neuroscience-institute-will-study-variety-of-brain-disorders.

205. *Google Firm Hopes to Control Organs with Electrical Signals*, NEW SCIENTIST (Aug. 1, 2016), https://www.newscientist.com/article/2099472-google-firm-hopes-to-control-organs-with-electrical-signals/.

206. Jacqueline Fellows, *Hospitals Bet on Neuroscience*, HEALTHLEADERS MEDIA (Feb. 4, 2016), http://www.healthleadersmedia.com/physician-leaders/hospitals-bet-neuroscience ("Neuroscience may be a clinical mainstay at hospitals and health systems, but new technologies are helping to reinvigorate the service line.").

207. *See, e.g.*, Huda Akil et al., *Neuroscience Training for the 21st Century*, 90 NEURON 917 (2016); Susan G. Amara et al., *Neuroscience in Recession?*, 12 NATURE REVS. NEUROSCIENCE 297 (2011); Alan I. Leshner, *Seize the Neuroscience Moment*, 342 SCI. 533 (2013).

208. *See, e.g.*, *Neuroscience and Law Center*, FORDHAM UNIV. SCH. LAW, https://www.fordham.edu/info/24639/neuroscience_and_law_center (last visited Jan. 5, 2017); *SPINS: The Stanford Program in Neuroscience and Society*, STANFORD NEUROSCIENCE INST., https://neuroscience.stanford.edu/initiatives/spins-stanford-program-neuroscience-and-society (last visited Jan. 17, 2017); U. OF PA. CTR. FOR NEUROSCIENCE & SOC'Y, http://neuroethics.upenn.edu/ (last visited Jan. 17, 2017).

209. Henry T. Greely, *Neuroethics and the BRAIN Initiative*, NEUROETHICS BLOG (Apr. 12, 2016), http://www.theneuroethicsblog.com/2016/04/neuroethics-and-brain-initiative.html.

further credit, the NIH solicited a Request for Information on "Guidance for Opportunities in Neuroethics (NIH BRAIN Initiative)."[210]

But NIH BRAIN funding is not enough. If it is to thrive, Law and Neuroscience 2.0 must involve a combination of private-sector partnerships, philanthropy, and government investment. (This formula, of course, would apply to many successful endeavors.)

Law and Neuroscience 2.0 must involve better partnerships with the private sector. To date, neurolaw has had little interaction with the growing world of neurotechnology finance and investing. The Neurotechnology Industry Organization (NIO), started by Zach Lynch, runs a number of initiatives that invite collaboration, for instance in government and regulatory affairs, developing public-private partnerships, and creating policy environments that foster innovation in brain-science private sector activity.[211] The organization sponsors regular meetings on neurotech investing, and also publishes market research related to neurotech. The conferences include diverse perspectives from pharmaceuticals, devices, diagnostics, and software.[212]

Even a cursory review of the conference programs, however, reveals that there is a marked difference between the interests of current investors and innovators in neurotech, and the concerns of legal academics writing in the neurolaw space. We ought to be more in tune with the private sector.

Finding mutually beneficial partnerships with such firms might provide neurolaw both with avenues for cutting-edge research, and with additional resources to carry it out.

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210. *Request for Information (RFI): Guidance for Opportunities in Neuroethics (NIH BRAIN Initiative)*, NAT'L INSTS. HEALTH, https://grants.nih.gov/grants/guide/notice-files/NOT-MH-16-014.html (last visited Jan. 5, 2017).

211. The NIO describes itself as "the first and only trade group that lobbies on behalf of companies involved in neuroscience . . . NIO is working on programs that could translate into millions of dollars for your company's bottom-line and billions of dollars for commercial neuroscience. Your membership is critical to get our initiatives organized and passed . . . Since 2006, over 100 organizations have joined NIO in order to accelerate neurotechnology . . . in support of our mission to 'give the brain a voice.'" Alison Fenney, *Welcome*, NIO: NEUROTECHNOLOGY INDUS. ORG., http://www.neurotechindustry.org/welcome (last visited Jan. 7, 2017).

212. *Neurotech 2017*, NEUROTECH, http://www.neurotechconf.com/about (last visited Jan. 7, 2017) ("Now in its 12th year, the Neurotech Investing and Partnering Conference is the premier partnering and investing conference for the neurotechnology industry spanning pharmaceuticals, medical devices, software and diagnostics for the brain and nervous system.").

C. Careers in Neurolaw

Related to issues of funding are issues of human talent. On one hand, there is good news: we are seeing an increasing number of students with neuroscience training. Until the 1960s neuroscience departments and programs were "virtually unknown."[213] By 2000, however, a survey of programs found that they were "plentiful".[214] Growth continues today.[215] For instance, the University of Chicago just began offering a major in neuroscience in 2016.[216] And on the campus of Portland State University, students in 2016 were actively organizing to demand the creation of a neuroscience program.[217] Perhaps most impressive, Virginia Tech has created an entire "School of Neuroscience."[218] Two-hundred students have already signed up, and it is anticipated that a thousand will eventually be enrolled.[219]

But if more neuroscience students is the good news, the bad news is that it is unclear how to improve career success outside of the traditional (and quite limited) academic routes. The issue was addressed in 2014 at a workshop on Developing a 21st Century Neuroscience Workforce.[220] The post-workshop report noted that the "field of neuroscience finds itself in the midst of an era of unprecedented growth and popularity"[221] Yet at the same time "there is a feeling of doom and gloom regarding career prospects."[222] Story Landis, former director of the National Institute of Neurological Disorders and Stroke, went so far as to suggest that there is "a moral

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213. EDWARD M. STRICKER, THE 2000 ANDP SURVEY OF NEUROSCIENCE GRADUATE, POSTDOCTORAL, & UNDERGRADUATE PROGRAMS 1 (2000), https://www.sfn.org/~/media/SfN/Documents/Survey%20Reports/2000SurveyReport.ashx.

214. *Id.*

215. *See*, *e.g.*, ALAN F. SVED, REPORT OF SURVEY OF NEUROSCIENCE GRADUATE, POSTDOCTORAL, & UNDERGRADUATE PROGRAMS (ACADEMIC YEAR 2010-2011) 18 (2011), https://www.sfn.org/~/media/SfN/Documents/Professional%20Development/NDP/SurveyReportAY20102011.ashx (describing how undergraduate programs are one area of significant growth).

216. Anjali Dhillon, *University to Offer Neuroscience Major Starting in Fall 2016*, CHI. MAROON (May 13, 2016), https://www.chicagomaroon.com/2016/05/13/university-to-offer-neuroscience-major-starting-in-fall-2016/.

217. Catherine Johnson, *Students Campaign for Neuroscience Studies: Creating a Culture Behind the Science of Thinking*, PSU VANGUARD, (May 10, 2016), http://psuvanguard.com/students-campaign-for-neuroscience-studies/.

218. Luanne Rife, *Virginia Tech's Neuroscience School Aims to Connect Students, Researchers Across Disciplines*, ROANOKE TIMES (May 8, 2016), http://www.roanoke.com/business/news/blacksburg/virginia-tech-s-neuroscience-school-aims-to-connect-students-researchers/article_4a0209fc-1ccc-59d2-a1c4-bbd2e186f364.html.

219. *Id.*

220. INST. OF MED. OF THE NAT'L ACADS., DEVELOPING A 21ST CENTURY NEUROSCIENCE WORKFORCE: WORKSHOP SUMMARY (2015).

221. *Id.* at 3.

222. *Id.*

imperative to provide students with opportunities for training in non-academic careers."[223] If such an imperative exists, it is an opportunity to recruit those with neuroscience training into legal and policy spheres.

If we want more neuroscience-informed law students and attorneys, we need to improve the options for interdisciplinary training. I was fortunate in 2009 to receive a post-doctoral fellowship with the MacArthur Foundation Law and Neuroscience Project. But those fellowships no longer exist, and without formal career development training opportunities, our field faces a structural challenge.

This challenge often reaches me, in the form of a question from a student who says: I have an interest in neuroscience and law/society . . . but how can I pursue that? This question comes from undergraduates, law students, science PhD students, and MDs. That I have so often received this question suggests to me that there is (a) growing interest in this intersection, paired with (b) little clarity about how, exactly, to pursue it.

How can one pursue a career in neuroscience and law? The first, necessary step is to obtain working knowledge in (some aspects of) the law and in (some aspects of) neuroscience. To date, individuals have taken this first step in different ways.[224] For motivated and entrepreneurial students, most universities will now allow graduate studies that combine both legal and scientific studies. In addition, in recent years several formal training programs have emerged. For instance:

- The University of Wisconsin's Neuroscience, Public Policy, and Law program was founded in 2005 by neuroscientist Dr. Ron Kalil, with the help of a 2009 National Science Foundation grant. [225]
- The joint JD/PhD in neuroscience at Vanderbilt was founded in 2010.[226]
- In 2015, Duke University began offering a joint

223. *Id.* at 4. Landis was specifically referring to PhD students, but a similar imperative could be suggested about undergraduate training.

224. Duke neuroscientist Pate Skene, for instance, returned to law school mid-career. *Pate Skene '13*, DUKE L. (Oct. 15, 2010), https://law.duke.edu/news/pate-skene-13/.

225. *Career Opportunities*, UNIV. WIS. MADISON: NEUROSCIENCE & PUB. POL'Y PROGRAM http://npp.wisc.edu/careers.htm (last visited Jan. 17, 2017); *Neuroscience and Public Policy: Award Abstract #0849122*, NAT'L SCI. FOUND. http://www.nsf.gov/awardsearch/showAward?AWD_ID=0849122 (last visited Jan. 7, 2017).

226. Jim Patterson, *Innovative Vanderbilt Joint Degree Combines Neuroscience and Law*, VAND. UNIV. (Nov. 17, 2011, 10:59 AM), http://news.vanderbilt.edu/2011/11/brain-law/.

JD/MA in Bioethics and Science Policy.[227] Duke Professor Nita Farahany has also pioneered a Science, Law & Policy Laboratory.[228]

- In 2015, the University of Pennsylvania began offering law students an option to obtain a Certificate in Social, Cognitive, and Affective Neuroscience (SCAN).[229]

At present, and not surprisingly given their newness, these programs remain small. But we may see significant growth in the future.

Be it from one of these formal programs, or via a different route, what options are there for someone who has achieved sufficient training? There is not, it should be emphasized, a "do it all at once" path. As with any other joint training programs, graduates must make a choice. At present, that choice leads to one of three general career paths:

1. A lawyer, judge, law professor, policymaker, or government official who is committed to exploring how science (including neuroscience) can inform and improve their work.
2. A clinician, physician, or research scientist who is committed to understanding and investigating the social/legal/economic/etc implications of their work
3. An entrepreneurial collaborator who facilitates discussion between various groups, and runs intermediary bridging organizations to facilitate interdisciplinary conversation.

The aspiring neurolaw student must decide whether she wants to be a practicing neuroscientist who knows a lot about what goes on outside her lab, a practicing lawyer/policymaker who knows a lot about what goes on inside a lab, or someone in the middle.

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227. *New Dual-Degree Program Combines Law, Bioethics, and Science Policy*, DUKE L. (Feb. 18, 2015), https://law.duke.edu/news/new-dual-degree-program-combines-law-bioethics-and-science-policy/.

228. Tyler Lian, *New Lab Combines Science with Law and Policymaking*, DUKE CHRON. (Sept. 9, 2016) www.dukechronicle.com/article/2016/09/new-lab-combines-science-with-law-and-policymaking.

229. *SCAN Certificate Helps Law Students Use Neuroscience to Understand Human Behavior*, U. PA. L. SCH. (Mar. 2, 2015), https://www.law.upenn.edu/live/news/5382-scan-certificate-helps-law-students-use.

For a successful Law and Neuroscience 2.0, we must make these career paths viable. In particular, we must see growth in the first pathway: lawyers who experience value-added to their practice by learning about the human brain. Law and economics has prevailed because it has produced such value-added. A lawyer working on large financial transactions will benefit from understanding economics. To achieve long term success, neurolaw must find ways to make itself more relevant to practice. Most fundamentally, I believe this will happen through the demonstrated success of attorneys whose knowledge about the brain allows them to achieve greater success such as better negotiated contracts, improved outcomes for clients, and more productive and enjoyable careers.

IV. CONCLUSION: WAITING FOR NEUROSCIENCE

"As for the Future, your task is not to foresee, but to enable it." – French writer, Antoine de Saint-Exupery[230]

"People studying the ethical, legal, and social implications of neuroscience have to walk a tightrope." – Hank Greely[231]

Neurolaw will succeed if it can do what other successful bodies of knowledge do: improve health, generate wealth, promote justice, and make the world a better place.

The ingredients to do this are before us. We have rapidly developing and well-funded neuroscience. We have many pressing social and legal challenges to which that neuroscience might apply. And we have—thanks to the pioneers in the first waves of neurolaw—a strong foundation on which to build.

But, as the quotes at the top of this Part suggest, we have to walk a tightrope. We need imagination, but not too much. We need excitement, but not over-exuberance. We need passion, but also patience.

For Law and Neuroscience 2.0 to be successful, we must not sit idly while we wait for neuroscience to deliver something big. We must add to our important, futuristic "What if?" queries an entrepreneurial "What *now*?" mentality. We must look for ways that today—even with all the limits of current knowledge and technology—we can still improve law and policy.

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230. ANTOINE DE SAINT-EXUPERY, THE WISDOM OF THE SANDS 155 (Stuart Gilbert trans., Univ. of Chi. Press, 1979) (1950).

231. Greely, *Law and the Revolution in Neuroscience*, *supra* note 42, at 707.

It would be easy if neuroscience gave us magical tools. But neuroscience cannot do that. Neuroscience can give us wonderful, if incomplete, insights into the neural tissue that makes us who we are. Creating the magic is up to us.